SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1924.

GENERAL PHYSICS.

714. *New Instruments for Physical Measurements.* **W. H. Tschappat.** (Mechanical Engineering, 45. pp. 673–678, Dec., 1923.)—Details of some instruments recently designed and used in connection with research work of the U.S.A. Ordnance Department are given.

The accuracy of workmanship demanded in built-up gun construction led to the invention of the star gauge for accurate measurement of the bore of long tubes. The instrument consists of a long arm with four radial arms, two fixed to serve as guides, the other two, diametrically opposite, movable radially by a steel cone driven in the direction of the arm by a screw, being the measuring arms.

For measuring time intervals in connection with projectile velocity determinations, the Aberdeen chronograph was invented. A motor drives the chronograph drum, to which record paper is affixed, at a constant rate. To overcome the inaccuracy of wire screens, resulting from the failure of the modern sharp-nosed projectiles to break them immediately, screens are made of two sheets of tin or lead foil, separated by a thin sheet of insulating material. Puncturing makes contact between the two metal sheets, and closes the primary circuit of an induction coil; the secondary spark is recorded on the drum.

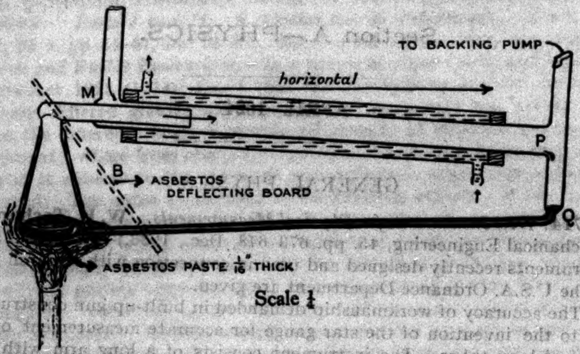
Air resistance of projectiles has been measured in a wind-channel, air speeds of 1600 ft./sec. having been obtained. It is also obtained by measurements of flight velocity at several points of the trajectory, and the solenoid chronograph was used in these determinations. The projectile is magnetised, and passes through coils of wire placed in its path. Its passage gives rise to an electric current in the coils, and these currents are recorded by an oscillograph, the time scale being supplied by a tuning-fork.

In connection with interior ballistics, the piezoelectric pressure gauge was designed. A quartz crystal separates two metal plates, and the piezoelectric charge developed under pressure is measured by a recording ballistic galvanometer.

To test the accuracy of these new instruments, a series of experiments on a howitzer mounted to allow free recoil was undertaken. By older methods, the distance-time curves for the projectile and gun were obtained

and consequently the forces and pressure at any time could be calculated. Comparison with the piezoelectric pressure records was good, and it was found possible to deduce the frictional force at the band of the projectile.
W. G. B.

715. *A Simplified Mercury-Vapour Pump.* **H. P. Waran.** (Journ. Sci. Instruments, 1. pp. 51–54, Nov., 1923.)—The glass work in the Volmer pump is unnecessarily complicated and not conducive to long life owing to local variations in temperature. For these reasons such pumps are usually made of hard glass and the idea is current that pumps made of soda glass are unworkable. There is no reason why pumps should not be made of ordinary glass and have as good a life as any other glassware, and a suitable design is illustrated and described. This can be used with a filter-backing pump down to 0·001 mm., but must be backed more efficiently for higher vacua.
G. A. S.



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716. *The Development of the Diffusion Air Pump.* **W. Gaede.** (Zeits. techn. Physik, 4. 10. pp. 337–369, 1923.)—A compendious report on the high vacuum air pump, in which it is shown that all the pumps produced by different inventors and firms for the production of very high vacua by means of mercury-vapour, depend on the diffusion principle discovered by the author. Langmuir's condensation theory is shown to have no importance, as his pumps are essentially diffusion pumps; this is also true of the Volmer pumps, which the inventor has described as vapour-jet and condensation pumps; of that of Crawford, which has been claimed to act as a "parallel jet" pump; of the Stintzing pump, which Gehrts also calls a parallel jet pump; and of the Brown-Boveri pump, for which the makers claim a special mode of action, which the author does not consider is the true one. The author's latest forms of pump are described, and measurements of their performance are given. The construction of his steel pump has been improved and simplified since the war, and in its latest and largest form the mercury-vapour is employed to produce three different steps of vacuum, the first step being by diffusion, the third step by ejector action of a vapour jet, and the second by diffusion when the pressure in the receiver is low, and by ejector action when it is higher; the same mercury vapour passes in succession through the three stages of the pump before passing to the receiver; the two lower stages 2 and 3 act as fore pumps; at 0·0001 mm. pressure an output of 80 litres per second was obtained with this pump with air, and 100 litres per second with hydrogen. The author's diffusion principle is fully explained, and the theory is worked out in detail, experiments being described which amply confirm its correctness. Briefly stated, a stream of mercury-vapour flows past an opening, the dimensions of which are not large compared with the free path of the gas molecules in the receiver; any vapour passing through the opening is condensed by means of a special condenser, and, the opening being small, the vapour stream into the receiver has not a high velocity, and air is able to diffuse from the receiver, through and against this side stream of vapour, into the main vapour stream, which carries it away, so that it is finally delivered to the fore pump. H. N. A.

717. *High-Vacuum Pumps.* **H. Ebert.** (Zeits. f. Physik, 19. 3. pp. 206–212, Nov. 14, 1923. From the Reichsanstalt.)—Comparative tests of the rate of suction by different types of pumps. The steel diffusion pump is by far the most rapid. A. D.

718. *Improvements in Mercury-Vapour Jet Pumps.* **H. Loosli** and **F. Lauster.** (Zeits. techn. Physik, 4. 10. pp. 392–394, 1923.)—The method of heating the mercury employed in a mercury-vapour jet pump of the Langmuir type is improved by the use of a heating coil wound with nickel-chromium in an atmosphere of hydrogen, and made up in the form of a cartridge which may be readily inserted into or withdrawn from the pump. The pressure in the vessel to be evacuated is reduced to about 18 mm. by means of a water pump. The pressure is further reduced to about 0·09 mm. by the jet pump, and still further reduced to 10^{-6} mm. by means of a second condensation pump. Preferably the mercury-vapour pump is operated in conjunction with a fall pump of the Sprengel type, so that each condensed globule of mercury, prior to returning to the vessel in which it is boiled, falls vertically through a capillary tube, and traps a bubble of gas which is later discharged into the atmosphere. The operation of the pump is still further improved by causing the jet of mercury-vapour to issue with parallel stream-line motion, and without turbulence, through a fine grating or series of concentric annuli. J. S. G. T.

719. *Trevelyan Rocker.* **S. Bhargava** and **R. N. Ghosh.** (Phys. Rev. 22. pp. 517–521, Nov., 1923.)—On the gravity theory (edges pushed up by expanding lead and brought down by gravity) the period of vibration would be given by $T^2 = 32k^2\beta/a$, where k is the radius of gyration, β is the maximum angular amplitude, and $2a$ is the distance apart of edges. Photographic methods confirm this. Transverse elastic vibrations, if present, are relatively weak. A. D.

720. *Joseph Henry.* **E. W. Rice, Jr.** (Gen. El. Rev. 27. pp. 85–89, Feb., 1924.)—Historical.

721. *Angle of Contact between Paraffin Wax and Water.* **A. Ferguson.** (Phil. Mag. 47. pp. 91–93, Jan., 1924.)—In criticism of R. Ablett's paper [see Abstract 184 (1924)], it is claimed that extrapolation of the law down to small contact angles is unjustifiable, and that Ablett's explanation given

in discussion of the previous results obtained by the present author [see Abstract 283 (1922)] must be rejected since whilst these experiments are statical in character, Ablett's experiments are essentially dynamical.
A. B. C. L.

722. *Certain Interfacial Tension Equilibria important in Flotation.* **W. H. Coghill** and **C. O. Anderson.** (Bureau of Mines, Techn. Paper No. 262 [54 pp.], 1923.)—The first section of the paper considers the equilibrium conditions along a line at which there meet two liquids and a gas. Lenses of paraffin and other oils, floating on water contained in a crystallising dish, were observed through a cathetometer, and by considering the levels of top and bottom of the lens, and the free surface of the water, and also by measurements of the angles of contact, values for the interfacial tensions were obtained. These agreed, and also gave closed "Neumann triangles." It was also found that *small* drops of a heavier liquid can be floated on a lighter, provided one interfacial tension is greater than the sum of the other two. The strengths of soap solutions that would float on benzene were predicted, and experimentally verified.

In the second section, the equilibrium along a line where a solid, a liquid, and a gas meet is considered. Provided the angle of contact of the liquid and solid is not zero, cylinders of the solid can be floated on the liquid, if they have a *sufficiently small* diameter. The presence of edges, however, increases the floatability of solids to a marked extent. Reasoning from the behaviour of a tumbler gradually over-filled, the mode of action was made clear. An edge must be considered as a region where the inclination of the face of the solid is rapidly changing. When the edge of the liquid reaches the inner edge of the tumbler, and more liquid is added, the meniscus becomes flatter, and ultimately convex, but the angle of contact, with some element of the inner edge of the rim, remains constant, the element altering as filling proceeds. When the liquid surface has risen sufficiently to make the angle of contact with the upper face of the rim, the liquid proceeds to advance over this face until it is brought to a stop at the outer edge. Similar phenomena now occur, until the surface of the liquid at its edge becomes horizontal, or until the angle of contact is made with the outer surface, and then overflowing commences. By undercutting the edge, the second of these possibilities may be delayed, but the first ultimately ensues, and if the solid angle is less than the angle of contact, it determines overflowing. It was deduced from this reasoning that a plate with an undercut groove on its upper surface should be floatable, whatever its size, so long as its weight per unit area was not greater than the hydrostatic pressure due to the maximum superelevation of the liquid. Plates conforming to this specification were prepared, and floated.
W. G. B.

723. *The Waves Due to a Single Impulse in Deep and Shallow Water.* **G. Green.** (Phil. Mag. 47. pp. 183–196, Jan., 1924.)—Closer approximations to the form of the waves are obtained.
W. G. B.

724. *Measurement of Thin Elastic Plates.* **C. Chéneveau** and **J. Callame.** (Comptes Rendus, 177. pp. 872–874, Nov. 5, 1923.)—Describes a form of apparatus devised for measuring accurately the thickness of a thin plate of elastic material. A vertical rod, bearing a fiducial mark, rests on the plate so that the pressure is constant and as small as possible.

The height of the mark is measured by means of a microscope. The pressure may be altered, if desired, by placing weights on a pan carried at the top of the rod. J. W. T. W.

725. *Surface Waves.* **F. M. Exner.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 4–5. pp. 365–382, 1922.)—The theory of waves at the surface of a fluid is developed, and differential equations for their description obtained. The theory is applied to three types of such waves: the high-water tidal wave; the surface waves of the sea; and the waves at the surface separating cold and warm layers of the air, which are important meteorologically. W. A. R.

726. *Rapid Determination of Watch Rate.* **A. Jaquerod.** (Arch. des Sciences, 5. pp. 469–477, Nov.–Dec., 1923.)—The watch is placed face downward, and an intermittent light, controlled by a regulator whose rate is very good, is reflected from the screw heads on the balance, at such times that the balance is at the extremity of its course. Such reflections are called coincidences, and if the watch gains or loses on the regulator, there will be coincidences at regular intervals, which are smaller the greater the differences in rates between the two timekeepers. The author describes the method of observation and of producing the intermittent light, and especially the electrical contact adapted to the regulator, which has been used elsewhere, but nowhere described. He points out that his method will give the mean rate for an hour, instead of merely the mean rate for twenty-four hours which may include widely different rates for different times of the day or night, depending on varying pressure, or temperature, or on some factor connected with the length of time since the watch was wound up. He cites examples of observations. A. S. D. M.

727. *The Measurement of High Pressures.* **F. H. Newman.** (World Power, 1. pp. 85–90, Feb., 1924.)

728. *Surface Tension of a Small Quantity of Liquid.* **A. Ferguson.** (Phys. Soc., Proc. 36. pp. 37–43; Disc., 44. Dec., 1923.)—If a cubic millimetre or less of a liquid be placed in a vertical capillary tube its surface tension can be determined by applying pressure to the upper end of the tube and measuring the pressure necessary to force the liquid into such a position that the meniscus at the lower end of the tube is plane. Without any special precautions as regards temperature this gives results with a probable error of only 0·3 %. Figures are given for benzene and water. Interfacial tensions with small quantities of liquids may be similarly determined. If a large amount of liquid is available a simple apparatus can be used, by which ordinary and interfacial surface tensions can be measured in several different ways. By using a very small quantity of liquid errors in the density attributed to it can be made negligible. A clear-cut meniscus is easily obtained with immiscible liquids. G. A. S.

729. *A Relation between Surface Tension and Density.* **A. Ferguson.** (Faraday Soc., Trans. 19. pp. 407–412; Disc., 412–413, Nov., 1923.)—The application is considered of the expression developed by Macleod [Abstract 190 (1924)] for representing the surface tension of unassociated liquids according to which $\gamma = C(\rho_l - \rho_v)^4$ where γ is the surface tension, and ρ_l and ρ_v the densities of liquid and vapour.

By considering data from a large number of organic liquids, it is found that the following relation $\gamma = \gamma_0(1 - bt)^n$ is closely followed, in which the mean value of n is $1 \cdot 21$, and b is a constant, equal to the reciprocal of the critical temperature. From this relation and expressions derived by van der Waals and by Katayama, the Macleod equation is derived and the constant C is found to be given by the expression $\Delta\theta_c/(M^{2/3}\rho_c^{10/3})$, where Δ is a derived constant which, as a first approximation, may be assumed to be independent of the nature of the liquid ; M is the molecular weight, ρ_c the critical density, and θ_c the critical temperature. Data from a number of liquids including critical constants determined by Young, show that the fourth-power law is followed satisfactorily, but the difference with some liquids is sufficiently great to lead to a modification in the value of the index. A close agreement is obtained between observed and calculated values of C. It is shown that the formulæ which are derived can be applied to form a basis for empirical relations put forward by Walden and by Ramsay and Shields on specific cohesion and capillary rise in tubes. J. N. P.

730. *Measurement of Hardness.* **Plaut.** (Zeits. f. Metallkunde, 15. pp. 328–334, Dec., 1923.)—A survey is made of the subjects of hardness, strength, and cohesion.

The technical methods of determining hardness are discussed, particularly the Brinell ball test, the scratch hardness test of Martens, and the rebound method of Shore. An attempt is made to correlate the results of hardness determinations with crystal structure as determined by the Röngten-ray method. F. J. B.

731. *Proportionality of Mass and Weight.* **H. H. Potter.** (Roy. Soc., Proc. 104. pp. 588–610, Dec., 1923.)—It appears possible that there may be slight differences in the gravitational constants of different substances according as the nuclei contain different proportions of hydrogen and helium atoms [see Abstract 1234 (1922)]. The author has carried out experiments on a number of substances suitable for exhibiting such differences if they exist and finds no difference greater than that attributable to experimental error ($<$ 1 part in 50,000). Special attention was given to two substances, ammonium fluoride and paraffin wax, which have large hydrogen contents. J. W. T. W.

732. *Dutch Pendulum Observations in Submarines.* **J. J. A. Muller.** (Nature, 112. p. 788, Dec. 1, 1923.)—Gives some of the results of pendulum observations on a Dutch submarine proceeding to Java. The Eötvös effect (difference of apparent value of g for E.–W. and W.–E. courses) gave the speed of the vessel to within $0 \cdot 3$ knots. With a sea depth of 2500 m., the value of g obtained differed from the theoretical by no more than $0 \cdot 003$ cm./sec.^{2}, pointing to complete isostasy. W. G. B.

733. *Viscosity of Steam.* **H. Speyerer.** (Zeits. techn. Physik, 4. 11. pp. 430–432, 1923.)—Using the method of flow through a tube, it is found that at a pressure of $1 \cdot 06$ standard atmosphere the viscosity of steam, η, is related to the temperature, t, by the equation

$$10^6\eta = 125 \cdot 40 + 0 \cdot 3711(t - 100) \text{ dyne sec./cm.}^2$$

for the range 100° C. to 350° C. Further experiments using higher pressures are in progress. G. A. S.

734. *Intermittent Projector for Movement Detection.* **F. Goos** and **P. P. Koch.** (Zeits. Instrumentenk. 43. pp. 337–340, Dec., 1923.)—Describes an instrument by means of which slight changes in a complicated system may be detected. Two photographs of the system are taken and these are projected alternately into the field of view of the observer, by means of a rotating shutter moving over a lens. A slight difference between the photographs at any point is detected by a blurring of the alternated image at that point. J. W. T. W.

735. *The Theoretical Scattering of Smoke in a Turbulent Atmosphere.* **O. F. T. Roberts.** (Roy. Soc., Proc. 104. pp. 640–654, Dec., 1923.)—The fundamental result of Taylor's paper, "Eddy Motion in the Atmosphere" [see Abstract 536 (1915)] is that the scattering in a turbulent atmosphere of suspended matter, or diffusion of potential temperature, may be regarded as analogous to the diffusion of heat in a solid; on this theory every point in the atmosphere possess a coefficient of eddy-diffusion K, which may vary from point to point, and which may further differ for diffusion in different directions at any one point, analogous to the diffusion of heat in crystalline substances. For the case in which K is the same at every point in the atmosphere the density of suspended matter, χ gms. per cm.^{3}, must satisfy:

$$(\partial/\partial t + u\partial/\partial x + v\partial/\partial y + w\partial/\partial z)\chi = K\nabla^2\chi,$$

where u, v, w are the components of mean velocity of the air. The purpose of this paper is to obtain solutions of the above equation applicable to several methods of artificial smoke production, *viz.*: (*a*) A puff of smoke due to the instantaneous generation of matter at a point; (*b*) a smoke-cloud produced continuously and uniformly at a fixed point in a uniform wind; (*c*) a smoke-cloud produced continuously and uniformly along an unlimited straight line perpendicular to the direction of a uniform wind. A theory of the optical opacity of smoke-clouds is then developed; an expression for the visible outline in terms of the density distribution is obtained, and applied to cases (*a*) and (*b*) for an observer situated at a great distance across wind from the cloud. An extension of the above results to the case of K non-isotropic is then made. Diagrams illustrative of the above results are given. H. H. Ho.

736. *Use of Medians for Reducing Observations.* **F. Y. Edgeworth.** (Phil. Mag. 46. pp. 1074–1088, Dec., 1923.)—This paper is supplementary to two earlier articles by the author (Phil. Mag. Aug., 1887, and March, 1888), who here further discusses the relative advantages and disadvantages of the median method in comparison with the method of least squares. His general conclusion is that the use of the median, single or double, is often easier, and sometimes more accurate than the method of least squares. He fully agrees with Laplace that in certain cases the situation, or single median, method is preferable to the method of least squares, and that in general it is natural to look upon the median as a very good approximation. A number of illustrations of sets of observations, mostly astronomical, are considered in detail. G. W. de T.

737. *Bending Stresses in Thin-Walled Tubes.* **J. Case.** (Phil. Mag. 47. pp. 197–208, Jan., 1924.)—A method is developed for calculating the strength of thin tubular beams. It is shown that any section of a beam of circular cross-section behaves as a ring under an external radial pressure which varies from point to point round the circumference. This pressure produces a bending moment which acts in the plane of the cross-section and has a maximum value $M^2r^3t/4EI^2$, where M is the bending moment applied to the beam, r is the mean radius of the cross-section, t is the thickness of the walls of the tube, I is the moment of inertia of the cross-section, and E is Young's modulus. This bending moment gives rise to a circumferential stress $\frac{3}{2} \cdot \frac{M^2r^3}{EI^2t}$ at the points of the section which are in the principal plane of bending and points which are separated from these by 90°. It is shown that this stress exceeds the longitudinal stress "f" if r/t is greater than $E/\frac{3}{2}f$, so that for mild steel, taking $E = 30 \times 10^6$ lbs./sq. in. and $f =$ the yield point for the material $= 50{,}000$ lbs./sq. in., the circumferential stress will cause failure if the dia. of the tube is 800 times the thickness. A similar expression is given for elliptical tubes and the theory is extended to apply to submarine hulls. J. V. H.

738. *The Resistance of Air to Falling Spheres.* **R. G. Lunnon.** (Phil. Mag. 47. pp. 173–182, Jan., 1924.)—Space-time records were obtained for spheres of different sizes falling in air by timing falls from various heights (up to 690 metres) in coal pits. After correcting for the variations of air density, etc., it is found that the simple square law of resistance is inadequate to express the results. The formula proposed is $R = \phi d^2v^2 + bv$. The value for ϕ is 132, and of b, $0 \cdot 55d^2$, in c.g.s. units. W. G. B.

739. *Eötvös Balance.* **W. Schweydar.** (Zeits. Instrumentenk. 43. pp. 307–311, Oct., 1923.)—Further field observations of records on the Eötvös balance by the photographic method are given in reply to Pekár's criticism. [See Abstract 1730 (1923).] W. A. R.

740. *Mechanical Properties of Mono-Molecular Films on Water.* **P. Woog.** (Comptes Rendus, 177. pp. 1107–1109, Nov. 26, 1923.)—This paper deals in a general way with the breaking up of the drops and the formation of films when small quantities of various oils are placed on water. It is suggested that the results observed throw light on the mechanism of liquid cohesion. A. A. D.

741. *Inversion Temperatures of Air.* **O. Knoblauch.** (Phys. Zeits. 24. pp. 473–474, Nov. 1–15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—For 125 atm. the lower inversion-temperature is about −140° C., and for 150 atm. about −133° C. A. D.

742. *Further Tests upon Dewar Flasks Intended to Hold Liquid Air.* **H. Briggs and J. Mallinson.** (Roy. Soc. Edinburgh, Proc. 43. 2. pp. 160–169, 1922–1923.)—A continuation of previous work [Abstract 931 (1922)], the object here being to obtain data in regard to the decay of the vacua of metallic Dewar vessels (containing charcoal). Most of the tests are on 3-litre flasks of gilding metal (95 % Cu, 5 % Sn). The apparatus employed allows the pressure of gas in the flask to be measured by a M'Leod gauge; the outer envelope is punctured and the puncture can again be sealed off *in vacuo*. For the 3-litre flasks the average rate of decay of the vacuum is $0 \cdot 093$ mm. of Hg per month. The evaporation rates of liquid air from the flasks bear no relation whatever to the pressure inside the envelope.

The authors state in conclusion that the "neck-loss" of a container of the usual design is negligible, and that if the pressure be as much as 0·1 mm. the charcoal is able to reduce the pressure sufficiently to make the conduction loss negligible also. The entire evaporative loss is then due to radiation. An improvement in the evaporative rate can only be secured by greater attention to the polish of the reflecting surfaces and to the means of preserving the lustre up to the time of evacuation. More data are desirable on the rate of tarnishing. Though the minimum emissivity of pure copper is much less than that of brass, the latter is better able to maintain a polish and may, in actual service, preserve an emissivity as low as, or even lower than, that of Cu. The accumulation of gas in a vessel standing empty is able in time to impair the reflecting power of the surfaces by oxidation. It is waste of time and money to exhaust very completely the envelope (evacuation to 0·1 or 0·2 mm. is sufficient). A vessel evacuated more completely will last longer than one less completely evacuated, but it is cheaper to obtain the relatively short additional life by using a little more charcoal than by prolonging the process of evacuation. T. H.

743. *Tables of Bessel Functions.* **H. E. H. Wrinch** and **Dorothy Wrinch.** (Phil. Mag. 45. pp. 846–849, May, 1923, and 47. pp. 62–65, Jan., 1924.)

744. *Tensile Strength of Glass.* **J. T. Littleton, Jr.** (Phys. Rev. 22, pp. 510–516, Nov., 1923.)—Previous results are inconsistent and unreliable because the strength of the surface is greatly reduced by slight scratches. Such effects are eliminated in the present method in which a bar of glass is used that has been cut from the middle of a slab, the latter having been heat treated in such a way as to leave the upper and lower surfaces of the bar under high compression while the middle is under tension. When, therefore, this bar is broken by bending, the tension introduced in the lower surface is largely neutralised by the initial compression, so that the maximum tension is not in the lower surface, but in a layer inside. The initial stresses are measured by means of polarised sodium light and a calibrated Babinet compensator, and these, combined graphically with the stress due to the load required to break the bar, give the maximum tension introduced, which is taken as the lower limit of the strength of the glass. The question as to whether the properties of the glass are altered by the heat treatment is discussed and answered in the negative. Also the cases in which the initial compression is greatest, *i.e.* those cases in which surface effects would be least important, give the highest values for the breaking stress. Values of 12 and 15 kg./sq. mm. were obtained for a lead glass and a boro-silicate glass, values twice as great as those usually found; the mean deviation of individual measurements is less than half as great as usual. G. A. S.

745. *Photo-Elastic Constants of Four Substances.* **P. Heymans** and **W. P. Allis.** (Math. and Phys. J. Massachusetts, 2. pp. 216–233, Dec., 1923.)—Properties of chief importance in photo-elastic work are investigated for celluloid (two kinds), glass and fused quartz, with a view to determining which substance is most suitable for the construction of models of machinery the stresses in which can then be found optically. A table of results is given from which it is deduced that apart from cost, quartz is the most suitable of the materials examined. G. A. S.

746. *Experimental Determination of the Inertia of a Sphere Vibrating in a Liquid.* **N. G. Krishnaiyar.** (Phil. Mag. 46. pp. 1049–1053, Dec., 1923.)—The spheres are fixed to a wire carrying a small current, placed between the poles of an electromagnet actuated by a single-phase alternating current, and under tension which is altered so as to give the maximum amplitude of vibration. Comparison of the tensions when the whole is immersed in air and water gives the effective increase of inertia due to immersion. The mean value of the increase so found is 0·583 of the mass of the fluid displaced. This is greater than the theoretical value obtained by Stokes, but the discrepancy may be due to the frictional resistance obeying the square law, and to the restriction of the space by the magnets, etc. W. G. B.

747. *The Initial Motion of a Projectile.* **E. T. Hanson.** (Phil. Mag. 46. pp. 1027–1048, Dec., 1923.)—Using the force system recently obtained by a combination of theory and experiment [see Abstract 1231 (1922)], which takes a simple form at high velocities, the motion of a shell during the first 7 or 8 seconds of its flight is calculated. The paper is mainly mathematical. W. G. B.

748. *The Reserve of Power of Birds in Flight.* **E. Huguenard, A. Magnan,** and **A. Planiol.** (Comptes Rendus, 177. pp. 1009–1012, Nov. 19, 1923.)—One end of a silk fibre is attached to a bird which in flying unwinds it from a pulley. The pulley revolutions are counted, and by means of a small Prony brake attached, the pull the bird is able to exert is determined. For the carrier pigeons used, the specific power is found to vary from 2·6 kgm./sec./kg. at 6 m./sec., to 0·7 at 12 m./sec. W. G. B.

749. *Hydrodynamic Similarity.* **C. Camichel** and **L. Escande.** (Rev. Gén. d'Él. 15. pp. 83–86, Jan. 19, 1924.)—Experiments with scale models verify, for five different cases, Froude's law that velocity varies with the square root of the ratio of linear dimensions. S. L. S.

750. *Whirling of Shafts.* **J. Frith** and **F. Buckingham.** (Inst. El. Eng., J. 62. pp. 107–113, Jan., 1924.)—A theory is advanced that whirling is essentially a case of vibration. This is supported by proving that the phenomenon obeys the laws of vibration, in particular those relating to the phase change between disturbing force and resulting displacement. The practical case of a shaft having initial eccentricity which provides the disturbing force is investigated analytically, and experimental verification is adduced of the theories put forward. A bibliography of the subject is given. J. V. H.

751. *Crystal Structure of the Surface Layer of Treated Metals.* **L. Thomassen.** (Zeits. f. Metallkunde, 15. p. 306, Nov., 1923.)—Application of Debye and Scherrer's method of X-ray analysis [Abstract 1140 (1917)] to a turned rod of commercial zinc gives a photograph showing practically only quite small streaks, which combine to the ordinary lines of a Debye photograph. When the diameter of the rod is reduced from 2·10 to 1·96 mm. by etching with dilute nitric acid, the streaks no longer appear, being replaced by large flecks. If, however, a fresh rod is treated with emery and on the polishing wheel, the fine streaks in the

Debye photograph are largely suppressed, the lines showing uniform darkening. Thus polishing causes the "smearing" of the crystalline fragments of the surface to proceed to a greater extent than turning in the lathe. Magnesium exhibits a similar phenomenon. T. H. P.

752. *Crystalline Structure of Metals, Mixed Crystals, and Intermetallic Compounds.* **K. Becker.** (Zeits. f. Metallkunde, 15. pp. 303–305, Nov., 1923.)—A *résumé* of the subject, with bibliography. T. H. P.

753. *The Crystal Structures of Lithium Iodide and Rubidium Fluoride.* **R. W. G. Wyckoff** and **E. W. Posnjak.** (Washington Acad. Sci., J. 13. pp. 393–397, Nov. 4, 1923.)—Lithium iodide as ordinarily prepared crystallises as a hydrate (trihydrate, dihydrate, and monohydrate). The anhydrous salt is obtained by heating the monohydrate above 300° C. The authors' determination was made with the anhydrous salt [see Abstract 1842 (1922)], though the resulting powder photographs showed that probably not less than 20 per cent. of the sample was hydrated. W. P. Davey simply evaporated a solution of LiI over sulphuric acid; under these conditions an anhydrous product is not produced at room temperature, and the fact that the interatomic distances as determined by Davey do not follow the same additive law as in the case of the other alkaline halides, the nearest approach of the Li and I atoms being 3·537 Å., while the additive law gives 3·01 Å., shows that he was not dealing with the anhydrous salt. The value deduced from the authors' measurements for the above distance was 3·015 Å., and the density, $\rho = 4\cdot 03$, agrees with that found by the usual methods. It is now found that a certain discrepancy, previously noted in the relative intensities of the lines, is accounted for by the hydrate mixed with the anhydrous salt, and that, when allowance is made for the fact that one of the hydrate lines coincides with an anhydrous salt line, the observed and calculated intensities are practically identical. The fact that in Davey's experiments one or more compounds, neither of which probably forms cubic crystals, could give as many as 20 lines which agree in position with a simple cubic arrangement, is a striking illustration of the danger of using the powder method by itself. The observed intensities, however, do not agree with the calculated ones. Rubidium fluoride is so hygroscopic that it alters at once on exposure to air, and the authors consider that the rubidium fluoride employed by Davey was not anhydrous; the observed distance between the atoms was 3·172 Å., while that calculated from the additive law is 2·80 Å.; the observed intensities of the reflections do not agree with those calculated for the stated atomic arrangement. H. N. A.

754. *Atomic Structure and the Reflection of X-Rays by Crystals.* **D. R. Hartree.** (Phil. Mag. 46. pp. 1091–1111, Dec., 1923.)—In a recent paper the author has attempted to determine, approximately, the field inside, and in the neighourhood of an atom, by quantitative analysis of the terms appearing in the optical and X-ray spectra, following the theory given in a more qualitative form by Bohr; the dimensions of the orbits could be calculated approximately from the results of this analysis, and applied to the problem of the intensity of the reflection of X-rays by crystals, and some preliminary results of this application to sodium were quoted and compared with the results of W. L. Bragg, R. W. James, and C. H. Bosanquet [Abstract 285 (1923)]. In the present paper this application is considered in detail, and the possibility of obtaining evidence on the orientations of the orbits in the atom, and the relative phases of the electrons, from X-ray reflection is discussed. Use is made of the factor F^2 in the formula as given by Bragg for the intensity of X-ray reflection; its value is first calculated with different distributions of the electrons in orbits, the actual moving distribution being averaged out into a spherically symmetrical distribution of charge (A); a similar calculation is made with the planes of the orbits fixed, when the circular orbit averages out into a ring distribution of charge (B); finally F is calculated where the normals to the planes of the orbits make fixed angles with the axis of the atom, but are capable of rotation round that axis; the atom axes are parallel to the three crystal axes and distributed equally among them (C). Comparison with the experimental data, dealing with the intensity of reflection from the different crystal planes, seems to indicate that this last atom, with the electron distribution $2\,1_1$, $4\,2_1$, $4\,2_2$, gives the best agreement. This represents the positively charged Na ion, and it seems clear from the dimensions found for this, and for the uncharged atom, that it is the ion which occurs in the NaCl crystal. The negatively charged Cl ion, with the electron distribution $2\,1_1$, $4\,2_1$, $4\,2_2$, $4\,3_1$, $4\,3_2$, and orbit positions C, gives greater differences between the calculated and observed values than in the case of sodium, the observed values being too small; reasons are suggested for this. For mathematical and other details the original paper should be consulted. H. N. A.

755. *X-Ray Investigation of Certain Organic Esters and Other Long-Chain Compounds.* **G. Shearer.** (Chem. Soc., J. 123. pp. 3152–3156, Dec., 1923.)—The author refers to Müller's results with some of the higher fatty acids [Abstract 14 (1924)] and describes experiments using a similar experimental method, the substance, however, being mounted in the form of a very thin layer on a strip of mica which was oscillated through about 8° on either side of the X-ray beam; the lines characteristic of the substance investigated, and the K_α and K_β reflections from the mica, appear on the photographic plate, and the latter give exceedingly sharp lines corresponding to a spacing of 10·1 Å., and calibrate the plate automatically. The methyl, ethyl, octyl, and cetyl esters of palmitic acid, the methyl and ethyl of stearic acid, and three chain compounds, which possess a benzene group, were investigated. For the palmitates $\Delta d_1/\Delta n = 1{\cdot}22$ Å., where d_1 is the cleavage spacing, n the number of CH_2 groups in the chain, and $\Delta d_1/\Delta n$ is the increase of spacing per CH_2 group. Müller found for the fatty acids 2·0 Å.; but points out that the length of the cell is probably that of two molecules. The stearates are longer than the palmitates; the increase per carbon atom on the acid side of the molecule is 1·0 Å. which agrees with Müller's results. The accepted diameter of C is 1·5 Å., so that, either the general direction of the molecules is not even approximately perpendicular to the cleavage planes, or the carbon atoms of the chain are arranged in some spiral or zig-zag fashion. Observations with the compounds containing a benzene ring show spacings of about double amount, with about twice as much increase per CH_2 group, so that it would seem that the "cell" contains two molecules placed end to end. The difference in length between the molecules of octa-decylbenzene and *p* octadecylphenol is 1·0 Å., which is about what is to be expected for the O atom, which forms the only difference between the two molecules. H. N. A.

756. *Further X-Ray Measurements of Long-Chain Compounds and their Interpretation.* **A. Müller and G. Shearer.** (Chem. Soc,. J. 123. pp. 3156–3164, Dec., 1923.)—The authors discuss results of previous papers (see preceding abstract] and gives values of d_1, d_2, and d_3 for eight new acids. It is only by a complete investigation of the crystal structure that the dimensions of the molecule can be determined; it happens, however, that, in the case of the long-chain compounds investigated, there appears to be a very close connection between the length of the molecule and the spacing d, of the cleavage planes; it is necessary to conclude that, for any one series, the molecules are all inclined at the same angle to this plane. In the case of the acids there are probably two molecules between two successive cleavage planes, arranged end to end in opposite directions. The average increase per CH_2 group, on this assumption, is for the acids 1·0 Å., while the "diameter" of the carbon atom is 1·5 Å.; if the molecules are perpendicular to the cleavage planes the carbons must be connected together, not in straight lines, but in spirals or zig-zags. In the diamond structure the angle between the lines joining the centre of a carbon atom to the centres of two of its neighbour atoms is 109° 28′, and different forms of chain are considered and illustrated, in which the positions of the atoms are governed by this angle. The longest possible chain is such that all the atoms are in one plane, and arranged in zig-zag fashion; this gives an increase of 1·22 Å. per carbon atom; a spiral arrangement, with the same angle between the lines joining the centres of successive pairs of atoms, gives an increase of 1·12 Å.; there is a third arrangement, also zig-zag, in which the lines joining successive pairs of atoms are perpendicular to the cleavage plane, and the line joining the centres of the top atom of one pair to the bottom atom of the one above it is inclined 109° 28′ to the perpendicular; the average increase of length per atom is 1·0 Å.; this agrees with the value found for the acids, while that for the first chain agrees with that found for the esters. For further details the original paper should be consulted. H. N. A.

757. *The Study of Stress-Strain Problems by Means of Röntgen Rays.* (Engineering, 116. pp. 750–751, Dec. 14, and pp. 762–763, Dec. 21, 1923.)—Gives a number of Laue diagrams (photographs) obtained by Dr. Czochralski for aluminium; it is shown that a very simple Laue diagram is obtained when the X-ray beam falls on a single crystal; with a large number of crystals in the field the dots become more numerous, more crowded, smaller, and fainter, until the halo pattern of an amorphous material, without dots, is approached. In the next series of experiments the specimens were stressed before the diagrams were taken; a Brinell ball 2 mm. in diameter was forced into slabs of single crystal, with pressures of 1, 3, and 5 kg. at the place through which the X-rays afterwards passed, and the full round dots obtained before this treatment were found to change their appearance and, to a lesser extent, their relative positions; they look more like drawn-out lenticular curves; for the higher pressures this becomes more pronounced, the lower dots approach the dark central spot closely, and the dots develop radial appendages. With a larger ball, and 10 kg. pressure, the dots disappear, and an "asterism" is formed round the central spot. Pricking a crystal with a steel needle to a depth of only 0·1 mm. caused the round dots to assume the lenticular form. Somewhat similar results were obtained by stretching the crystals, and by rolling them out into foil. On the strength of these and other researches Czochralski maintains that the "strengthening" which cold work imparts to metals cannot be ascribed to the formation of an amorphous layer, or explained by a "translation hypothesis," involving flow and slip lines; but must be attributed to a "dislocation" in the lattice structure. Attention is called to the work of A. Ono, F. Körber and Polányi, and the author of the paper concludes that, whatever the facts may be as to the behaviour of slip planes, sooner or later the lattice itself must be disturbed or dislocated, and that Czochralski's photographs suggest that this disturbance must set in at an early stage, and proceed gradually. H. N. A.

758. *Rotational Specific Heat and Half Quantum Numbers.* **R. C. Tolman.** (Phys. Rev. 22. pp. 470–478, Nov., 1923.)—It is shown from a consideration of infra-red rotation-oscillation spectra, that the lowest possible azimuthal quantum number for a non-oscillating rotating molecule of the rigid "dumb-bell" model can have only the values zero, one, or one-half. An elementary theory of quantisation in space for the new case of half quantum numbers is then developed which shows that the *a priori* probabilities for successive levels of rotational energy stand in the ratios of 1, 2, 3. . . . The specific heat curve for diatomic hydrogen to 300° K is then calculated on the basis of the energy levels and of *a priori* probabilities corresponding to half quantum numbers, and is compared with the experimental points and with the curves calculated by Reiche using zero and one as the lowest possible azimuthal quantum number. At low temperatures the new curve agrees with the experimental data as well as any curve of Reiche's. At the higher temperatures, none of the curves agree with all the experimental points. *The moment of inertia for the hydrogen molecule* corresponding to the new curve is $J=1\cdot387 \times 10^{-41}$ gm. cm.^{2}, about two-thirds the values assumed by Reiche, $2\cdot095$ to $2\cdot293 \times 10^{-41}$, and agrees better with the conclusion of Sommerfeld from the separation of lines in the many-lined spectrum of hydrogen, that the moment of inertia of an excited hydrogen molecule is $1\cdot9 \times 10^{-41}$ gm. cm.^{2} which should be greater than that of the unexcited molecules involved in specific heats. Hence the possibility of half quantum numbers seems worthy of consideration. AUTHOR.

759. *Energy in Radiation.* **W. Bothe.** (Zeits. f. Physik, 20. 2. pp. 145–152, 1923.)—Statistical methods give for the mean square of energy-fluctuations $\Delta^2 = kT^2(\partial E/\partial T)$ where E is the mean energy of a system, T the temperature, and k Boltzmann's constant. With Planck's equation this becomes $\Delta^2 = h\nu E + (hE^2/a\nu^2 V)$. If we assume quanta to be discrete and independent, we get $\Delta^2 = h\nu E$ only, whereas if we assume quanta to be associated as singles, doublets, triplets, etc., in numbers determined by a probability law but involving no work upon association or separation, we obtain for Δ^2 the former, the statistical expression. A. D.

760. *Some Approximate Numerical Applications of Bohr's Theory of Spectra.* **D. R. Hartree.** (Cambridge Phil. Soc., Proc. 21. pp. 625–641, Nov., 1923.)—Accepting Bohr's theory of atomic structure, an attempt is made at the determination of an electric field such that the orbits specified by the application of the quantum conditions to the motion of an electron in this field shall have the energies assigned to the different terms in the optical and X-ray spectra. The dimensions of the orbits can then be calculated, though exact agreement is not to be expected. Only atoms which in the normal state have one electron only in the most lightly bound type of orbit are considered, for example K, ionised calcium, and sodium. The field at distance r is thought of as due to a charge Ze and the problem is the determination of Z as a function of ρ, where $\rho = r/a$, a being the radius of the hydrogen 1_1 orbit, such that for a given n and k the values of ν/R calculated from the equation $n - k = 1/2\pi\int\left(-\frac{\nu}{\mathrm{R}} + 2v - \frac{k_2}{\rho^2}\right)^{1/2}d\rho$ become as nearly as possible those of the terms of the optical and X-Ray spectra. $v = \int^{\infty}\frac{\mathrm{Z}}{\rho^2}d\rho$ and for circular orbits $\mathrm{Z}\rho = k^2$.

No details of atomic structure are postulated. The "added fields," *i.e.* the fields which may be thought of as superimposed on the field of an H nucleus, become appreciable a long way outside the boundary of the atom, precluding the possibility of central symmetry. This "added field" is very much smaller for Ca than for K. Z – K at the boundary of the atom is nearly the same for all the atoms, Ke being the net charge on the kernel.

An explanation of the abnormal value of a in Hicks' sequence formula is given in terms of the rapid variation of "added field" in the region of the 3_3 orbit. W. V. M.

761. *Difficulties of the Quantum Theory of Atomic Construction.* **A. Landé.** (Phys. Zeits. 24. pp. 441–444, Oct. 15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—The author enumerates, "in somewhat apodictic fashion," quoting his own words, a number of the difficulties referred to in the title. G. W. DE T.

762. *Quantum Theory of Radiation Equilibrium.* **A. Einstein** and **P. Ehrenfest.** (Zeits. f. Physik, 19. 5–6. pp. 301–306, 1923.)—Pauli's proposed statistical law of probabilities (Zeits. f. Phys., 1923) for the impulsions of quanta in radiation seems at first sight to lead to paradoxical conclusions; but a careful investigation, starting from first principles, gives results which agree with it. A. D.

763. *Quasi-Ergodic Motions and the Quantum Theory.* **P. Ehrenfest.** (Zeits. f. Physik, 19. 4. pp. 242–245, 1923.)—The author posits the question: Can a system with s degrees of freedom have more than $2s-1$ independent frequencies? He has not found an answer to the general question, the objective put forward being to formulate a hypothesis capable of being either definitely proved or disproved. Consider a system with s degrees of freedom and Hamiltonian function $\mathrm{H}(q,p)$, then, in quasi-ergodic motion [see Abstract 1779 (1923)], its phase path in the $2s$-dimensional q,p space, in the course of its motion passes indefinitely near, in general, to every point of a ρ-dimensional domain. This domain lies in the $2s-1$ dimensional energy surface $\mathrm{H}(q,p) = \mathrm{E}$. If $\rho = 1$, the motion has only one frequency; the maximum value of ρ is $2s-1$, when the motion is quasi-ergodic. Now at each passage of the phase path at a minimum distance from the energy surface not only q,p and $\dot{q},\dot{p}$, but the higher derivatives also are to a very close approximation equal for all the frequencies. Now it is shown earlier in the paper that for a single frequency movement in a plane the phase path is a closed curve, and for a manifold frequency the phase path will either occupy a two-dimensional domain G_2 or be infinitely near to a three-dimensional domain G_3. In the latter case the motion will be quasi-ergodic. Then, guided by this analogy and the above-mentioned considerations, the author formulates his hypothesis as follows: Assume, in the general case, a quasi-ergodic motion with manifold frequency to be representable by G_ρ motions in which the q's and p's, in their dependence upon the time, are representable by u-fold Fourier series, $u = \rho$ and consequently has the maximum value $2s-1$. If it be substantiated, it will follow that, in the sense of the foregoing representations, systems may be found of manifold frequency in which $s < u \leq 2s - 1$. These would not be subject to quantum conditions, which require $u \leq s$. G. W. DE T.

764. *Degenerate Systems in the Disturbed Motion Calculus.* **L. Nordheim.** (Zeits. f. Physik, 21. 4. pp. 242–246, 1924.)—The author in this paper calls attention to an error made by him in his calculation of the higher approximations in a former paper [Abstract 25 (1924)]. He here replaces the faulty procedure by an investigation which W. Pauli was kind enough to send him. G. W. DE T.

765. *Precision of Michelson's Experiment.* **E. Brylinski.** (Comptes Rendus, 177. pp. 1209–1210, Dec. 3, 1923.)—Discusses the theoretical basis of the experiment, and shows that according to the conditions prevailing, *i.e.* geographical position, date, and hour of day, the displacement of the interference fringes may vary greatly, and will in general be less than those predicted on previous theories. The displacement may even be zero in a considerable number of cases. J. W. T. W.

766. *Einstein Theory.* **P. Drumaux.** (Assoc. Ing. Él. Liége, Bull. 1. Ser. 7. pp. 233–252, July; 277–291, Aug.–Sept.; 314–326, Oct., and pp. 342–366, Nov.–Dec., 1923.)—On the basis of a postulate that Space, Time, Mass, and Movement are inseparably connected by measurable relations, the author develops the Einstein theory. A. D.

767. *The Special Relativity Theory and Velocities* $> c$. **L. Strüm.** (Zeits. f. Physik, 20. 1. pp. 36–44, 1923.)—Velocities $> c$ would not be in disaccord with the theory. Not only questions of simultaneity and of time-duration but also of time-direction, come under the theory. For velocities $> c$, the phenomena would occur in the region of the Minkowski world hitherto excluded, outside the 4-dimensional cone $x^2 + y^2 + z^2 - u^2 = 0$, with time in a reversed direction. A. D.

768. *Contradictions between Ether Theory and Relativity Theory.* **E. Gehrcke.** (Zeits. techn. Physik, 4. 9. pp. 292–299, 1923.)—A general review gleaned from papers and books by Michelson, Morley, Miller, Gerben, Righi, Birkeland, Niedermöller, St. John, Sagnac, von Soldner, Mohorovičić, Försterling, Bucherer, Wiechert, Lenard, and others.
G. W. DE T.

769. *The Behaviour of Light from Extra-Terrestrial Sources.* **R. Tomaschek.** (Ann. d. Physik, 73. 1–2. pp. 105–126, Dec., 1923.)—The object of the research described was to find if it was possible by means of the Michelson interference experiment to show the existence of an absolute reference system, the Uräther of Lenard. Light from the sun, moon, Jupiter, and the fixed stars Arcturus and Vega was examined by a special arrangement of Michelson's apparatus, but the results were negative, no shifting of the interference bands was observed. Thus the light quanta examined no longer travel in the Uräther of interstellar space, but have assumed a light velocity relative to the ether of the earth, which is at rest relatively to the earth's surface. J. J. S.

770. *Propagation of Light in Interstellar Space.* **P. Lenard.** (Ann. d. Physik, 73. 1–2. pp. 89–104, Dec., 1923.)—A discussion of the behaviour of light in view of the results of recent experiment: (1) The action of gravity on light quanta as indicated by the deflection of light rays by the sun; (2) the negative outcome of Tomaschek's repetition of Michelson's experiment with light from the sun, moon, and planets, and, which is specially important, with fixed star light. The author brings forward the hypothesis of an ether which fills interstellar space—the " Uräther "—and does not share in the motion of the heavenly bodies, while to each heavenly body is ascribed its own ether which surrounds it like an atmosphere and partakes in its velocity. In the ether of the earth all light quanta of whatever origin travel relatively to this ether with the light velocity c, just as also all light quanta do in the province of one of the other heavenly bodies relatively to the ether there; from star to star on the contrary light velocity relative to the Uräther prevails. J. J. S.

771. *Gravitational Displacement of Solar Lines.* **C. E. St. John.** (Roy. Astron. Soc., M.N. 84. pp. 93–96, Dec., 1923.)—Pressure, anomalous refraction, motion in the line of sight, gravitational shift, and differential scattering are taken into consideration as causes for the displacement of the Fraunhofer lines. Pressure is found to be a small fraction of a terrestrial atmosphere, and is therefore out of count. Anomalous refraction requires high density-gradients, and these are wanting. From a study of 300–400 iron lines, a comparison of the solar wave-lengths and laboratory wave-lengths *in vacuo* give the former as the larger, and when the calculated Einstein effect is deducted from the differences, the discrepancies are systematic and greater than errors of observation. These discrepancies are attributed, partly to radial velocities of moderate cosmic magnitude and in probable directions, and partly to differential scattering in the longer paths traversed through the solar atmosphere at the limb of the sun. A. S. D. M.

METEOROLOGY AND GEO-PHYSICS.

772. *Optical Soundings of the Atmosphere.* **(Miss) E. Bellemin.** (Comptes Rendus, 177. pp. 1316–1319, Dec. 10, 1923.)—Information concerning currents in the upper air may be obtained from the results of optical soundings. Observations have been made of the height H, above the horizon, where the scintillation of stars ceases to be accompanied by changes of colour. The values of H have been classified into 4 zones: I. 0°–24° above the horizon; II. 24°–34°; III. 34°–44°; IV. 44°–64°. At the beginning of periods of fine weather, H lies either in zone I. or II.; in periods of intermittent rain, H is generally in III. or IV. If H passes quickly from zone I. or II. to zone III. or IV. the approach of a storm is indicated. These measurements may be of value in making forecasts for a comparatively long period. A. W. L.

773. *Improved Method of Computing Meteorological Normals.* **H. W. Clough.** (Monthly Weather Rev. 51. pp. 391–395, Aug., 1923. Paper read before the Am. Meteorolog. Soc., Washington, April, 1923.)—Modifications of the least square method for the determination of meteorological normals, and their advantages over the arithmetic mean of a number of observations, are discussed. The methods are illustrated by: (1) The determination of the period, and the average date of maximum, of rainfall at San Francisco—treated statistically; (2) computation of the mean annual temperature at Washington—treated both statistically and graphically. In these methods relatively greater weight is given to the terms in the middle of the series. A. W. L.

774. *The Law of Pressure Ratios and its Application to the Charting of Isobars in the Lower Levels of the Troposphere.* **C. L. Meisinger.** (Monthly Weather Rev. 51. pp. 437–448, Sept., 1923.)—A method of charting isobars at heights of 1 and 2 km. has been described in earlier papers [Abstract 833 (1923)]. The data for several stations shows that the relation between p_z/p_s (the ratio of the pressure at a height z to that at the surface), and p_2/p_1 (the ratio between the pressures at 2 and 1 km.), is approximately linear if z is $<$ 5 km. Thus, $p_z/p_s = (a \, . \, p_2/p_1) + b$; this is termed the law of pressure ratios. The values of a and b, corresponding with heights of 3, 4, and 5 km., have been obtained by the method of least squares from the observed pressures at several aerological stations; these values are corrected for the variation of the mean of a number of observations at a given station from the annual mean. A study of the probable errors involved shows that the order of accuracy for the higher levels is the same as that at 2 km.; this is confirmed by comparing the observed pressures at higher levels with the values computed from surface conditions. The values of a, corresponding with different heights, and corrected for the height of the station above sea-level, are charted. These charts show a region of low values in the middle latitudes of the Eastern U.S., with a steep horizontal gradient to the south and a slight gradient to the north. The values of b for non-aerological stations may be found from the values of a given by these charts and interpolated values of mean annual pressures. A. W. L.

775. *Group Distribution and Periodicity of Annual Rainfall Amounts.* **R. E. Horton.** (Monthly Weather Rev. 51. pp. 515–521, Oct., 1923.)—In annual rainfall and other data, it is often noticed that there is a tendency for the occurrence of groups of successive years all above or all below normal. The occurrence of such runs of "wet" and "dry" years in actual data is discussed in relation to the probability of groups of different lengths in a chance distribution. This leads to a simple criterion of the existence of periodicity in the data. A useful feature of the paper is a reproduction of the annual values of precipitation from the long record at Padua (176 years, 1725–1900). M. A. G.

776. *Meteorological Observations at Saint Maurice in* 1922. **R. Gautier and E. Rod.** (Arch. des Sciences, 5. pp. 478–488, Nov.–Dec., 1923.)—See also Abstract 426 (1923).

777. *Meteorological Observations at Rio de Janeiro,* 1920. (Boletim Meteorologico, [152 pp.] 1923.)—General observations at the national observatory during 1920.

778. *Auroræ, Sunspots, and Magnetic Variations during* 1921. **W. E. W. Jackson.** (Roy. Astron. Soc. Canada, J. 17. pp. 361–364, Nov.–Dec., 1923.)—Sets out graphically the auroral intensity, Wolfer sunspot numbers, and range of vertical force, horizontal force and declination at Agincourt, for each day of the year 1921, in order to show to what extent there is agreement between times of maxima and minima of the various curves. While there are some striking coincidences, there are equally striking discrepancies. The "auroral intensity" is based on reports from meteorological observers at stations scattered over Canada, the "intensity" on a particular day being taken as measured by the number of observers seeing aurora on that day. Also compares the "mean daily range" (R) of declination and horizontal force at Agincourt for each of the years 1898 to 1921 with the mean sunspot numbers (S). There is a close linear relationship given by :—

For declination, $R = 8'\cdot 374 + 0\cdot 0343\,S$.

For horizontal force, $R = 27\cdot 926\,\gamma + 0\cdot 2209\,S$.

M. A. G.

779. *Actinometer.* **Henry.** (Comptes Rendus, 177. pp. 1323–1326, Dec. 10, 1923.)—A new type of Arago actinometer is described. The two spheres are completely enclosed in glass, and the temperature is read from a tellurium-nickel thermo-couple, giving a current so strong that the ordinary laboratory galvanometer can be used. *Radiation.*—The instrument showed that with covered sky the negative radiation ceased 25 mins. before sunrise, and on one occasion commenced before sunset, but became positive again one hour after sunset. This reversal has been observed also on other occasions. W. A. R.

780. *Influence of Barometric Pressure on the Specific Gravity of the Surface Water in the Indian Ocean.* **R. B. S. Sewell.** (Nature, 112. pp. 789–790, Dec. 1, 1923.)—Daily variations of these quantities are found to be correlated, and this is explained as being due to the upwelling of water from deeper levels. During the monsoons, the surface water is relatively light, so a high barometer goes with a low surface specific gravity. In the drier seasons, the reverse occurs. W. G. B.

781. *Earthquake Surface Waves.* **B. Gutenberg.** (Phys. Zeits. 24. pp. 458–459, Nov. 1–15, 1923.)—The Chili earthquake of Nov. 11, 1922, gave two groups of surface waves. The first had a period of 1 min.–2½ mins. ; a constant speed of propagation from 4⅓–4½ km./sec. ; and an absorption coefficient of from 0·00010–0·00015. The second group had a period less than ¾ min., whilst its speed was smaller, and its absorption greater than the first group. It is suggested that the long-period waves depend chiefly on the elasticity of the deeper layers ; and the second group on the structure of the surface layers. Exactly what type of wave was involved could not be determined with certainty. W. A. R.

782. *Magnetic and Gravity Anomalies at Koursk, Russia.* **P. Lasareff.** (Comptes Rendus, 177. pp. 1232–1234, Dec. 3, 1923.)—Two

roughly parallel belts, running from the N.W.-S.E., showing marked anomalies were investigated. The passage from marked to feeble anomalies was sharp. The isolines showed the existence of a maximal line, which was called the *anomaly axis*. The vertical magnetic component varied along the axis; the declination changed from E. to W. on crossing it in a N.E. direction, and the minima values of the horizontal component segregated about this line. The gravity anomalies did not necessarily coincide with the magnetic, but they enabled a prediction that the cause of the anomalies was not the existence of telluric currents, but a bed of magnetite deeply buried. A special investigation was undertaken to verify this conclusion, and at a depth of 150 m. a mass of magnetite was discovered (associated with quartzites), impure at the surface but enriching considerably downwards, and of great extent.
W. A. R.

783. *Gravity Results in Mackenzie Basin.* **A. H. Miller.** (Roy. Astron. Soc. Canada, J. 17. pp. 367–373, Nov.–Dec., 1923.)—A map is given of the nine gravity stations established in 1921–22 in the Mackenzie River basin. The times of vibrations of the bronze pendulums, "invariable" except for changes due to temperature variations, are compared with those obtained at Ottawa, where the force of gravity is known; the value of gravity thus is found at all the stations. Ottawa's gravity has been compared with Washington's and so with European stations, and the Canadian gravity determinations (of which there are now 51 stations) are comparable with those throughout the world. The results from the nine stations are summarised in two tables. Under "Corrections" in Table II, there is given the altitude correction and also that based on the theory of isostasy, which has been the most successful in predicting observed values. Hence the importance of the last column in this table, which gives the gravity anomalies. A. S. D. M.

784. *Earth-Current Measurement at Watheroo Magnetic Observatory.* **O. H. Gish.** (Terrest. Magn. 28. pp. 89–108, Sept., 1923.)—Complete description of earth currents requires a knowledge of the distribution of both earth resistivity and potential. This question is analysed, but the main consideration is directed to potential gradient. The case where the measuring lines are not at right angles is included. The apparatus in use at Watheroo is described with the aid of diagrams. The earthed points are arranged rectangularly, one limb running N. and the other E. from the vertex. The vertex is the common point of reference, and nearer points along the lines are also earthed. The potential difference between the nearer point on each limb and the vertex can be determined alternately by underground and overhead lines, and both types of transmission compared. Only overhead lines are available to the further points. W. A. R.

ASTRO-PHYSICS.

785. *Status of Observatory Work*, 1922. (Internat. Geodet. and Geophys. Union, Bull. No. 3. pp. 57–74, Oct., 1923.)

786. *Determination of Longitude of Innsbruck Observatory with the Aid of Wireless Signals from Nauen.* **A. Scheller.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 6–7. pp. 445–460, 1922.)—The mean of 16 determinations gives a longitude east of Greenwich = 45 m. 31·448 s., with a probable error of ±0·050 s. M. A. E.

787. *Occurrence and Distribution of Solar Faculæ in Latitude.* **Greenwich Observatory.** (Roy. Astron. Soc., M.N., 84. pp. 96–99, Dec., 1923.)—An analysis of the 70,000 measures of faculæ, observed at Greenwich, by plotting each group of faculæ for each rotation of the sun from 1874–1917 according to its latitude, and indicating its area by a certain thickness of line, after the method of E. W. Maunder's "butterfly diagram" for the latitude of sunspots. The facula zones are broader than the spot zones, and there is a zone of polar faculæ in both hemispheres near latitude 70°, but these do not seem to be connected with polar prominences. The faculæ unassociated with spots are small, faint areas lasting at the most for two months; the duration of faculæ connected with spots is, on the average, three times the life of the spot group. Faculæ tend to spread out in latitude; spot groups in longitude. A. S. D. M.

788. *Variations of Sun's Visible Features and of Solar Radiation.* **C. G. Abbot.** (Nat. Acad. Sci., Proc. 9. pp. 355–357, Oct., 1923.)—The author has compared direct solar photographs and H_α spectroheliograms from Mt. Wilson with the intensity of solar radiation outside our atmosphere, determined by the Smithsonian Institution; and finds: That higher radiation occurs when a spot group forms, or comes into view, at the east limb; that high radiation occurs when the solar surface is generally disturbed; that radiation tends to fall continually during solar quiescence; but that lower radiation occurs when a sunspot transits the central meridian of the sun, minimum usually taking place on the day following the transit. He recalls Guthnick's observation of variation in Saturn's light (Vol. IV, "Annals of the Astrophysical Observatory") with the solar constant as seen from the earth, due time being allowed for the presentation of that same solar longitude to Saturn, and attributes the fact to the diminished transparency by the coronal rays whose base lies upon the spot group. A. S. D. M.

789. *The Dielectric Constant of the Sun's Photosphere.* **W. Anderson.** (Zeits. f. Physik, 20. 3–4. pp. 166–169, 1923.)—Saha has come to the conclusion that the sun must be surrounded by an atmosphere of free electrons, and the author has made the further step of identifying this "electronic atmosphere" with the inner corona. Bottlinger has calculated the mean velocity of the electrons and shown it to be such as to cause the electron to leave the sun which thus becomes positively charged. According to calculations due to G. E. Hale, magnetic fields of the order of 1000 gauss are produced by the motion of this "atmosphere" and a cubic centimetre of gas must contain $2\cdot10^7$ electrons. It must therefore be assumed that the photosphere for 1000 km. deep has this excess of electrons and deep in the sun a great quantity of positive electricity must be stored. It is shown that the electron must be pulled downwards with a force more than $5\cdot10^{11}$ that acting on the heaviest neutral atom, while a positively charged atom must be acted on by a correspondingly large force. This result is not in agreement with Saha's, which show that the electrons are concentrated in the higher layers as they are lighter than the positively charged atomic nuclei, whereas it has been pointed out that it must be very much "heavier." The author is of the opinion that the solution lies in the assumption that the dielectric constant of the photosphere is not equal to unity but to a very large number, thus reducing the electrical forces. The dielectric constant must be of the order of 10^{18}. This implies on Maxwell's theory, a very large refractive index. The Drude formula for the refractive index of conductors is discussed and shown to give even larger ones, but for large conductivities $n^2 > \epsilon$, where n = refractive index and ϵ = dielectric constant if $\mu = 1$. It may happen that Drude's formula is not applicable to the photosphere, but it is still maintained that without proof there is a grave risk in assuming the dielectric constant to be equal to unity. W. V. M.

790. *The Apparent Distribution of Energy on the Solar Disc.* **A. Amerio.** (Accad. Sci. Torino, Atti, 58. 8. pp. 181–190, 1922–1923.)—In earlier work [Abstract 1389 (1915)] the author found that the apparent energy at the centre of the solar disc, as compared with that towards the margin, increased slightly with the altitude of the observing station. He has now investigated the effect of the different thicknesses of air traversed by the sun's rays during the hours of daylight, and has obtained well-marked confirmatory results. A. D.

791. *Consequences Following on the Fact that all Stars, including the Sun, must have passed through Nova Stage.* **E. Belot.** (Comptes Rendus, 177. pp. 947–948, Nov. 12, 1923.)—Arguing from Bailey's estimate of an annual average of 15 novæ, the author draws the consequence that all stars and therefore the sun, must have passed through a nova stage. He deduces that the theories of Russell and Eddington must be revised from this point of view and concludes that all stars have planetary and cometary systems, the diverging nebulosities of the novæ being the skin issuing from them to form planets. A. S. D. M.

792. *Photo-Visual Magnitudes of One Hundred Bright Stars.* **E. S. King.** (Harvard Coll. Abs., Annals, 85. 3. pp. 45–62, 1923.)

793. *Development of Faint Images in Fogging.* **S. R. Pike.** (Roy. Astron. Soc., M.N. 83. pp. 493–501, Oct., 1923.)—Quantitative measures of densities by means of a photoelectric cell and an optical wedge. An Ilford panchromatic process plate was exposed in six strips (A to F), parallel to its length, and in five strips (1 to 5) parallel to its breadth, for various periods of time, to a fixed source of red light, and developed with azol. The strips, 1 to 5, represent the faint images to be brought up, and the six strips, A to F, the foggings; the darker points at the junctions of the strips giving the blackenings of the "brought up" images. The density is defined as:

$$D = \log_{10} \frac{\text{(Intensity of incident light)}}{\text{(Intensity of transmitted light)}}.$$

Definite proof is obtained of an optimum fogging exposure which will bring out the faint image to the greatest possible extent; this "optimum" fogging for any given faint image depends only on the density of the image, and not at all on its past history, for images with the same density will give the same " curve," whether these images are produced by over-exposure and under-development, or by under-exposure and over-development; the separate times of exposure and development do not enter into the question. A. S. D. M.

794. *Study of Planetary Surfaces by Polarisation.* **B. Lyot.** (Comptes Rendus, 177. pp. 1015–1017, Nov. 19, 1923.)—By using a powerful polariscope on telescopes of 0·83-m. and 0·175-m. aperture, the author finds polarisation from planets where Savart had found none. The planet is observed in the eyepiece of a telescope with a polariscope, and simultaneously by means of an inclined mirror, so that its light is polarised, by turns, in two planes, parallel to and perpendicular to the principal section of the polariscope. Fringes are made to appear which are therefore of the same intensity, if the light of the planet is unpolarised, and of different intensities if it is slightly polarised. The polariscope and method of observing is described and a diagram is given of some of the results from Venus, of which 70 measures were made subsequent to 1922, May 13. When Venus was in quadrature or a crescent, the terminator was always more polarised than the limb, and the polarisation underwent irregular fluctuations which were not observed with angles less than 60°. A cloud of droplets gives, in effect, when examined in the laboratory, a polarisation curve similar to that found for Venus. A. S. D. M.

795. *Photographic Observations of Minor Planets in* 1922 *Obtained with the Franklin-Adams Star Camera.* (Union Obs. S. Africa, Circ. No. 57. pp. 187–193, April 10, 1923.)

796. *Comparison of Photographic Measures Made by Different Observers.* **E. S. King.** (Harvard Coll. Obs., Circ. No. 249. pp. 1–6, 1923.)—It is well known that the relative brightness of stars can be gauged by estimating the diameters and also the blackness of their images on a photographic plate. Tests have been made at Harvard College Observatory on the ability of different observers in this work by supplying a star photograph to be measured, and a scale consisting of a series of images of some star which has been photographed with exposures progressing in geometrical ratio. The plate is measured twice, and means of the two sets of measures are taken for each observer. It is found that the brightness of a star can be determined with an accuracy of about 0·07 magnitude, and that many persons, even without previous experience, are able to engage effectively in the work. M. A. E.

797. *Interferometer Measurement of Double Stars.* **M. Maggini.** (Accad. Lincei, Atti, 32. ii. pp. 20–24, July, 1923.)—Using the rotating interferometer, the measurements of double stars in the Burnham catalogue having a separation less than 0″·7 are given. The slits of the interferometer are set at an arbitrary distance apart D, and then turned so that the interference fringes show minimum visibility. This occurs for four positions in a complete revolution, and the two axes thus indicated lie at an angle $\pm\eta$ with the position of the double. The separation of the double is then given by the expression $\phi = \lambda/2D \cos \eta$. It is pointed out that an instrument of this type has a far greater effective resolving power than the telescope with which it is used. The results for 38 doubles

are tabulated and references given to other determinations with which they are compared. A. Wh.

798. *Mechanism and Structure of Planetary Nebulæ.* **J. H. Jeans.** (Roy. Astron. Soc., M.N. 83. pp. 481–493, Oct. 1923.)—An examination of the extent to which planetary forms can be explained as the result of joint action of gravitation, rotation, and light-pressure, from the light of a central star. It is found possible for absorbing matter to stand in equilibrium in layers surrounding the central star (1) without rotation, if $E/M > 4\pi\gamma C/\kappa$, but this only if E is not the total emission of radiation but is confined within a certain definite range of high frequency, and κ is the capacity of matter of a special kind for light of this frequency; (2) for rotation, with steady uniform angular velocity ω, for shells with inner and outer surfaces, given by negative and positive values of B respectively in the family, $\omega^2(x^2 + y^2)/2 + B/r = K$, ($\omega^2$, B, and K being constants.) Here again, it is assumed that the mechanical action of light-pressure is limited to a particular colour, say ultra-violet. The curves of these shells resemble roughly in many cases, those of known planetary nebulæ, and it is shown that the body of the nebula must be transparent for all practical purposes, so that the light which is photographically and visually active, is distinct from the light-pressure which is mechanically active. For the amounts contributed by different elements of the nebula, three hypotheses are considered: (1) That equal volumes, or (2) equal masses give equal light, or (3) that the emission of light is confined to regions in which the density is less than a certain critical quantity, ρ_0, and the author draws an analogy from the limitation of auroral light to regions in the earth's atmosphere where the density is less than a certain critical density. A. S. D. M.

799. *Derivation of Equations of Transfer of Radiation, and Application to Interior of Star.* **E. A. Milne.** (Cambridge Phil. Soc., Proc. 21. pp. 701–710, Nov., 1923.)—(1) For stellar radiative equilibrium, Eddington expands the radiation intensity in a series of Legendre functions of cos θ, $\Sigma A_n P_n$ (cos θ), where the A_n's are not determined explicitly, but each is very small as compared with its predecessor; the author expands in a power series in cos θ where the coefficients are found explicitly. (2) Eddington has shown that the mechanical effect of the radiation, on matter it is traversing, is approximately equivalent to that of a hydrostatic pressure p_r, the "pressure of radiation," given by $p_r = aT^4/3$, and this is the same as for isotropic black radiation. (3) If J denote the intensity of black body radiation, at temperature T, by Kirchhoff's law, the emission of energy per gramme of the material per second is $4\pi kbT^4$, and if $4\pi\epsilon$ denote the rate of internal generation of energy, per gramme, per second at any point, due to any process whatever, Eddington supposes that the material emits $4\pi\epsilon$ *together with* $4\pi kbT^4$, but according to the author the correct view is that the material simply emits $4\pi kbT^4$ and that $4\pi\epsilon$ is the balance between the amount emitted and the (smaller) amount absorbed, though the two views are equivalent for a first approximation. (4) For material stratified in parallel planes, Eddington's "pressure of radiation" becomes

$$P_r = 4\pi c^{-1}[J(\tau)/3 + J''(\tau)/5 + \dots]$$

where J, J′, J″, etc., are of the relative orders of magnitude of 1, 10^{-10}, 10^{-20}, etc. This argument, however, only holds good if $4\pi\epsilon$, the generation of energy, is small compared with $4\pi kb\mathrm{T}^4$, the total emission. The pressure of radiation is no longer, as in the isotropic case, exactly 1/3 of the energy-density. The error is given approximately by $p_r - \mathrm{E}/3 = \frac{4}{15} \cdot \frac{4\pi\epsilon}{ck}$. (5) For the general case the approximation to the formula as in the stratified case is $p_r = 4\pi\mathrm{J}/3c$. (6) If Eddington's view regarding the generation of energy is adopted instead of the author's, then the function J must be replaced by the function j, given by $j = \mathrm{J} + \epsilon/k$. A. S. D. M.

800. *Mean Absolute Magnitudes of K and M Giant Stars and Systematic Errors in Trigonometric Parallaxes.* **W. J. Luyten.** (Nat. Acad. Sci., Proc. 9. pp. 317–323, Sept., 1923.)—Van Rhijn, in a memoir on the relations between mean parallax, proper motion, and apparent magnitude, reached the conclusion that recent parallax determinations of stars with small proper motions are systematically too large. In his investigation he assumed that the distributions of the radial velocities and of the components of the proper motions are comparable with regard to direction and size. Owing to the importance of parallax statistics in stellar astronomy, the question is here investigated from another point of view, not making this assumption, and dealing with astrophysically homogeneous groups of stars, *i.e.* the Ko giants and the M giants. The conclusion reached is that the mean absolute magnitudes of the two groups are approximately $+ 0^{\mathrm{M}}\cdot 7$ and $- 0^{\mathrm{M}}\cdot 2$, and that the trigonometrical parallaxes, at least those of Allegheny Observatory, are not affected by large systematic errors. M. A. E.

801. *Formation of Planetary and Stellar Systems.* **A. Véronnet.** (Comptes Rendus, 177. pp. 624–627, Oct. 8, 1923.)—The evolution of a system consisting of a number of centres of condensation is discussed. Assuming first for simplicity a cubic-lattice spacing, the behaviour of a small collection of particles, initially at any point, is investigated. Hence it appears that the material will become concentrated into zones, and that these finally form the three elements of a solar system, the sun, the lesser planets, and the greater planets and comets. The formation of double stars is also explainable on these lines. It is also seen that the planets will revolve about their own axes in a direct sense.

A. Wh.

802. *Radial Velocities of Long-Period Variable Stars.* **P. W. Merrill.** (Mt. Wilson Observat. Contrib. No. 264. Astrophys. J. 58. pp. 215–262, Nov., 1923.)—Velocity observations have been made with two single-prism spectrographs, attached to the 60-in. and 100-in. reflectors, on the maximum phase of variables brighter than the 9th magnitude. Tables are given of wave-lengths of emission lines, of absorption lines (Class M_e), and of radial velocities of 117 variables. From emission lines a slight variation of velocity with phase seems to be indicated as real; and it is probable that the appearances of bright lines at different times in the light cycle are due to successive phases of the same disturbance, not to different outbursts. It is typical of these variables that the bright lines are displaced towards the violet with respect to the absorption spectrum; and this displacement (absorption *minus* emission-line velocity) increases with advancing spectral type, except in Class M_{3e}. It also increases on the average with period and magnitude range, but the true radial velocity is probably yielded by the absorption lines. From the absorption velocities, the speed of the sun is found to be almost three times that found from K and M stars, but the apex is almost the same. There are 68 stars with residuals less than 25 km., giving $V_0 = 48$ km., and 65 with larger residuals, $V_0 = 65$ km., but all indicate a strong group motion. The random motion decreases with advancing type, the more rapidly moving stars belong to the earlier spectral classes. Very high velocities are confined to stars having short periods. It is not confirmed that the apparently fainter variables are more rapid than the brighter. A. S. D. M.

803. *Interpretation of the Results of the American Einstein Expedition.* **J. Hopmann.** (Phys. Zeits. 24. pp. 476–484; Disc., 484–485, Nov. 1–15, 1923. Paper read before the Deut. Physikertag, Bonn, Sept., 1923.)—The writer considers that Einstein's general theory of relativity has not yet been definitely proved by any of the three tests. In his opinion much more work, extending over a long period of time, remains to be done in investigating both the movement of Mercury's perihelion and the shift of the solar lines to the red, before conclusive evidence can be obtained for or against the theory. He criticises the results obtained by the English eclipse expedition in 1919 and by Campbell and Trumpler in 1922, and argues that the displacements in star positions near the sun can be equally well explained by the Courvoisier effect of "yearly" or "cosmical" refraction. He urges that this effect should be further investigated by observers in different countries, and especially by observations of Venus at superior and inferior conjunction, and that at future eclipses it should be made possible to differentiate between Courvoisier and Einstein effects by (1) securing absolute, not merely relative, scales of the eclipse and control plates, and (2) by photographing a larger field extending to greater distances round the sun.

In the *discussion* which followed the reading of this paper, **Einstein** agreed that it was impossible to decide between Courvoisier's cosmic refraction and relativity effect by means of Campbell's measurements.

M. A. E.

804. *Internal Motions of Spiral Nebulæ.* **J. H. Jeans.** (Roy. Astron. Soc., M.N. 84. pp. 60–76, Dec., 1923.)—It has been shown by v. Pahlen that spiral nebulæ are all equiangular, and therefore if a spiral undergoes change, its new curve must also be equiangular. If $r = Ae^{\theta \tan \alpha}$ be the equation of the equiangular spiral of angle α, then van Maanen's transverse measures must conform to $\mu_{\text{trans.}} = r(a + b \log r)$, and the author finds that a is uniformly positive and b negative, and α decreases, so that the nebulæ considered are curling up more tightly. Analysing the forces that can produce the observed motion, the general equations are obtained $f_x = X - \frac{1}{\rho}\frac{\partial p}{\partial x}$, where (X, Y, Z) include all forces acting at a distance, and the other terms include all forces arising from the action of contiguous particles of matter or "ether." Electromagnetic forces, pressure of radiation and of gas, viscosity, etc., are all found to be negligible, so that the equation reduces to $f_x = X$, that is to gravitation. In such circumstances the orbits of particles should be of high eccentricity, and their velocities mainly radial. But in van Maanen's measurements, the radial velocity is much less (usually) than the rotational, so that gravitation cannot be the main force acting. The author investigates the types of force which can produce steady motion in which each particle moves along the spiral arm, and finds, that in the nebulæ measured, v^2 varies as $r^{\frac{1}{2}}$, and that there must be radial and tangential forces, both at work in addition to a gravitational force arising from the central nucleus; the resultant force being inclined at a small angle to the normal to the path. The new force appears to depend on the direction of the motion of the particle upon which it acts, suggesting that the specification of the force depends on the motion as well as the position of the particle, as it does in the case of electromagnetic forces. The general effect of the force is that the particle revolves about the nebula with the angular velocity of the nucleus itself, and therefore moves as if repelled from the nucleus, describing an orbit of ever-increasing radius, with ever-increasing velocity. The author concludes that this new force is insignificant in the solar system, but if operative within nebular nuclei, might account for the settling down of these to a uniform rotation within a reasonable time. A. S. D. M.

805. *Motions, Parallaxes, and Luminosities of Long-Period Variables and other Stars of Late Spectral Types.* **R. E. Wilson.** (Astron. J. 35. pp. 125–132, Nov. 26, 1923.)—In [Abstract 2128 (1923)] Astronomical Journal, 1923, the author published proper-motions of red Mc and Md stars; now in a table he gives 86 Ma and Mb stars. From these two lists he omits all having proper-motions in excess of 20″ per century, and from the 300 stars of late type left, he obtains a mean parallax of 0″·00398; a mean apparent magnitude at maximum of 7·3 and a mean absolute magnitude of + 0·3, showing that the added material produces no essential change in the tendencies of the stars. He proceeds, therefore, by the same methods to find the mean parallax of the other stars. But he urges caution in estimating the mean parallax from poorly determined proper-motions, and he finds that the weighted logarithmic mean of all the proper-motions, gives on the whole the best result for the mean μ. If proper-motions with probable errors $\gtrless$ 0″·010 or $\gtrless$ 0″·015 are used, the mean μ derived from them should be decreased 10 % and 20 % respectively in order to represent the true mean proper-motion. The mean absolute magnitudes are computed from $M = m + 5 + 5 \log \pi = 12 \cdot 5 + 5 \log \pi$. It is noted that stars whose light is variable, sometimes through a large range, yet have a very small range of mean absolute magnitude; these are giants, and it is therefore indicated for giants that the mean luminosity ranges little from F5 to S. But R and N stars (which are not usually variable) are definitely more luminous, and in N stars there is great range of luminosity. Another table gives the individual parallaxes derived for 139 stars of class M and later types, and these are in fair agreement with spectroscopic and trigonometrical parallaxes, as regards stars fainter than magnitude 2·0. A. S. D. M.

806. *Proper-Motions of Stars in Zone,* − 9° 50′ to − 14° 10′. **W. J. Luyten.** (Harvard Coll. Obs. Annals, 85. No. 2. pp. 35–44, 1923.)—The quantity $H = m + 5 + 5 \log \mu$, has been computed for stars of known spectra, and frequency curves of H have been compared for those in Boss's Catalogue with those in the Catalogues of Greenwich 1910, Harvard Annals 81, No. 1, and Cape Astrographic Standard Stars, indicating that the stars of F_0–F_8 differ from those of other spectral classes. The author considers seven possible sources of error, and concludes that the proper motions in the three zone catalogues, are systematically too large, and that the apparently fainter stars probably move faster than the apparently brighter stars. A. S. D. M.

807. *Variable Stars and the Velocity of Light.* **M. la Rosa.** (Accad. Lincei, Atti, 32. ii. pp. 117–121, Sept., 1923.)—Amplification and supplement to previous paper [Abstract 54 (1924)]. A. D.

808. *Light Curves of the Two Abnormal Variables T and R Coronæ Borealis.* **L. Campbell** and **H. Shapley.** (Harvard Coll. Obs. Circ. No. 247. pp. 1–4, 1923.)—These two stars, one a peculiar nova and the other a peculiar variable, are situated within a few degrees of one another in a high galactic latitude, and in this they differ from all other novæ (except those in spiral nebulæ) and all other variables of similar spectral type. The light-curve of T Coronæ has been derived from about 1700 observations made between 1866 and 1923, and shows, after the sudden rise from 9th to 2nd magnitude in 1866, an unusually rapid decline of six magnitudes in twelve days, followed by a period of almost stationary brightness during the last fifty years: the star, which appears to be now a giant of M type, has some peculiarities of detail in its spectrum. The light-curve of R Coronæ, based on about 15,000 observations from 1783 to 1923, is entirely irregular in period, but shows a remarkable approach to uniformity in brightness at its maxima: it is a giant of F or G type, with a peculiar and variable spectrum. It is suggested that the two stars may be at the same distance from the earth, in a region of space where some special condition causes abnormal variation. If this distance be assumed as about 800 parsecs, which would give plausible absolute magnitudes to each, their distance from one another is about fifty parsecs. Their proper motions are very small. M. A. E.

809. *Revised Magnitudes and Colour Indices of the Planets.* **E. S. King.** (Harvard Coll. Obs., Annals, 85. 4. pp. 63–71, 1923.)

810. *Relation between Visual Star Colours and Spectral Classes.* **W. S. Franks.** (Roy. Astron. Soc., M.N. 84. pp. 20–22, Nov., 1923.)—A table giving in condensed form the analysis of 5793 stars so as to determine the *mean* colour equivalent of all classes of stellar spectra, from O_a to N_c. The material is derived from the *Specola Vaticana,* 15, and the *Draper Catalogue.* A short description is also given of the peculiarities and colours of the various types. Of the O stars the most singular feature is that many are arranged in *pairs* of similar magnitude and spectral class within about 1° or so apart; the N_c class are the reddest of "red" stars, though there is no such thing as a *pure* red in stellar tints. The M_d stars are excluded from the analysis. A. S. D. M.

811. *Intensity-Distribution in Spectra as a Function of Spectral Type and Absolute Magnitude.* **B. Lindblad.** (Roy. Astron. Soc., M.N. 83. pp. 503–510, Oct., 1923.)—The author first explains what has been misunderstood by Lundmark and Luyten in his previous papers

[Abstracts 451 and 1085 (1923)]. For later type stars, the effective wave-length depends on the marked contrast in intensity between the two parts of the photographic spectrum separated by the G-band, and the increase in contrast is more rapid with the type than is allowed for by change of temperature in Planck's law. The author, therefore, forms a *local colour-equivalent* by comparing the exposure-ratios of λ4227 — G with G — λ4383 and for the cyanogen regions by the exposure-ratios between λ4144–4184 Å. and λ4227–4272 Å. He terms these two exposure-ratios "G" and "C" respectively, and a comparison between $\lambda_{eff.}$ and $\lambda_{min.}$ ought to bear analogy with the comparison of "G" and "C." The analogy between "G" and $\lambda_{eff.}$ is nearly perfect for types later than F_0, and there is a remarkable rate of change of the exposure-ratio with spectral type. The author suggests that the "photospheric" radiation of the sun has a sharp peak near G with an abrupt fall towards the shorter wave-lengths, so that for types a little later than the sun, this abrupt fall forms a complete break exactly at the G-band, and increases rapidly with decreasing effective temperature. Four diagrams are given, of which the last presents a spectro-photometric discrimination between "giants" and "dwarfs" for proper motion stars in Zone R.A. 21h. 50m. to 0h. 10m., Dec. 72° to 78°, the "dwarfs" and "giants" of types $G_0 - K_2$ being treated separately. A. S. D. M.

812. *Relationship between Absolute Magnitude and Spectral Class, Derived from Observation of Double Stars.* **K. Lundmark** and **W. J. Luyten.** (Astron. J. 35. pp. 93–95, Sept. 21, 1923.)—By assuming a relationship between difference of magnitude and difference of spectral type, the authors find that they can arrange 500 physically associated pairs of stars, whose spectra are known, in two curves corresponding to "giants" and "dwarfs." Of four of these double stars—α Centauri, α Aurigæ, ζ Urs. Maj., and θ Tauri—the absolute magnitudes are already known, and thus a correction can be applied to the absolute magnitudes assumed for each spectral class. A diagram gives the resulting relationship which is very close to that given by trigonometrical parallaxes, as far as the "dwarf" branch is concerned. A. S. D. M.

813. *H and K Lines of Calcium in O-Type Stars.* **J. S. Plaskett.** (Roy. Astron. Soc., M.N. 84. pp. 80–93, Dec., 1923.)—R. K. Young has shown that stationary H and K lines are not seen lower in the spectral sequence than B3; Fowler and Milne, that stellar H and K should disappear about B0. But stationary H and K, and D lines appear in all absorption O-types, whether binaries or not, and in Wolf-Rayet stars (emission O-types), and the velocity obtained from these is generally constant, and differs from those given by the other lines. A table is given of the H and K radial velocities, grouped first as to the positions of the stars in the sky, and next with respect to the differences in these velocities. Two hypotheses of their origin are discussed: (*a*) Of an interstellar vapour cloud between earth and star, and (*b*) of an enveloping cloud outside the normal stellar atmosphere. Since the H and K lines are sharp, and superposed, in some cases, on a continuous spectrum showing no other absorption lines, and are also found in the spectrum of a planetary nebula, and in some stages of development of the spectra of Novæ, a common origin must be assumed that is independent of the conditions prevailing in these various stellar types. The matter giving the sharp H and K, and D absorption lines must be distributed over wide areas in the sky, and not necessarily close to the Galaxy; it must also be nearly stationary with respect to the local stellar system; and very tenuous. H. H. Plaskett suggests that it is near to or envelops the stars generally, but is ionised by the radiation from the very high temperature stars only. Hubble has shown that O- and early B-type stars are near to, or in nebulosity, whose luminosity is excited by these stars, so that the calcium and sodium absorption may be similarly produced. Saha has also suggested that the stationary calcium may have been emitted by the stars themselves, but his suggestion would not explain sodium absorption. The author points out that the lines appearing are the first lines of the principal series of an alkali metal and an alkaline earth metal, and suggests lines to look for, which belong to other alkali metals or alkaline earths. A. S. D. M.

814. *Spectral Class, Apparent Magnitude and Galactic Positions of Stars of Henry Draper Catalogue.* **H. Shapley.** (Harvard Coll. Obs., Circ. No. 248, pp. 1–10, 1923.)—The positions of selected fields of one hundred square degrees outside the Galaxy are given, and a table showing the number of stars in each field for each spectral class and for different galactic longitudes and latitudes. The latter is summarised in a further table which shows that the concentration to the galactic plane is not uniform in all galactic longitudes. The author also gives in tabular form and in a figure the concentration of stars towards the galactic circle for all stars down to 8·25 mag., and for stars between 7·0 and 8·25, showing: (*a*) That A and K stars predominate especially in the Milky Way; (*b*) that there is little or no concentration of F and G stars; (*c*) that there is either discontinuity in spectral series or some important selection between types B8–A3 and A5–F2; (*d*) that stars are uniformly dense (except A stars) between 45° and 90° in both galactic hemispheres; and (*e*) that F, G, and M stars are slightly denser at the poles than at latitudes 60° and 75°, this feature being also conspicuous for K stars in the southern galactic hemisphere. The F and G stars in the catalogue are dwarfs as a general rule, the other classes are giants. The volume, in which are the B stars, is about 2000 times that of the G stars, which is roughly a million cubic parsecs; it is found that the relative frequency in space of G and B stars is about 2000 to 1. The distant Milky Way regions are represented chiefly by the giant stars. A. S. D. M.

LIGHT.

815. *Diffraction at the Edge of a Black Screen.* **E. Maey.** (Ann. d. Physik, 73. 1–2. pp. 16–20, Dec., 1923.)—Remarks on the previously published work by F. Kottler on this subject [see Abstract 1547 (1923)] which the author considers to mark a considerable advance in the treatment of the general problem. J. W. T. W.

816. *Practical Calculation of Lenses.* **P. Martinez.** (Riv. Ottica e Meccan. 2. pp. 36–51, July, 1923.)—A treatment, mainly mathematical of the method of calculating a cemented doublet free from spherical aberration. J. W. T. W.

817. *Simple Method of Studying the Performance of Optical Systems.* **V. Ronchi.** (Riv. Ottica e Meccan. 2. pp. 9–35, July, 1923.)—Describes a means for studying an optical system by the use of an object consisting of a fine network of lines. An image of this network, formed by the optical system under examination, is brought into coincidence with a second similar network, and from the appearance of the combination of this second object with the image of the first object the defects of the optical system may be detected. Photographs of the results obtained in certain practical cases are shown as examples in the paper. J. W. T. W.

818. *Scattering of Light by Carbon Dioxide, Nitrous Oxide and Some Organic Vapours.* **A. L. Narayan.** (Phys. Soc., Proc. 36. pp. 32–36, Dec., 1923.)—Lord Rayleigh has shown that the light scattered laterally by the molecules of gases is not completely polarised but contains a component polarised at right angles to the direction which is predicted by theory for a spherical molecule. In the experiments described in this paper sunlight was used for illuminating gases and vapours which were enclosed in a jointless tube. The strengths of the components were compared both by direct photometry and by photometric comparison of their effects on a photographic plate. Lord Rayleigh's results were confirmed, particularly in the case of CO_2 and N_2O. It is suggested that the difference in the scattering power of these two gases is contrary to the prediction of the Lewis-Langmuir theory of the atom. J. J. S.

819. *Twilight Sight with Telescopes.* **K. Krüger** and **J. Zenneck.** (Ann. d. Physik, 72. 3–4. pp. 242–248, Jan., 1924.)—Traces the improved vision in part to an involuntary adjustment of the telescope so as to bring the image into a position in which the effects of astigmatism (always more or less present) are minimised. In bright daylight this result is masked by the constriction of the iris. A. D.

820. *Fatigue Oscillations in Different Regions of the Spectrum.* **E. Haas.** (Comptes Rendus, 176. pp. 1831–1833, June 18, 1923.)—Broca and Sulzer have already investigated this effect, determined by the comparison of a surface steadily illuminated with one subjected to intermittent light, for white, red, green, and blue. The author repeats these observations for pure spectrum colours, and arrives at the conclusion that the effect is in inverse proportion to the luminous efficiency, being a maximum in the blue and a minimum in the green. But the relation apparently breaks down in the case of red light, and the author attributes this to the fact that personal errors in this region of the spectrum are usually pronounced. Thus Broca has found that when one attempts to compare photometrically the brightness of a red surface with that of some other colour results may vary in the ratio 4 : 1. The author's experiments with pure spectrum colours confirm the view that apparent variation in brightness due to short excitations is accompanied by alteration of hue. The degree of change depends upon the period of excitation. J. S. D.

821. *Resonance Theory of Colour Vision.* **F. Aigner.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 4–5. pp. 299–320, 1922.)—On investigation of the resonance curves a result is reached in which the complementary colours of the fundamental sensations play a remarkable rôle. The red curve attains its resonance maximum for the wave-length $\lambda = 577\,\mu\mu$; the resonance position lies therefore in the blue complement and so in the pure yellow. Its logarithmic decrement has the approximate value $\delta_r = 0 \cdot 704$. The green curve possesses with a logarithmic decrement of $\delta_g = 0 \cdot 528$ its middle vibration maximum in the field of constant intensity distribution at $\lambda = 550\,\mu\mu$, thus in the ordinate maximum of the cone curve. The most interesting result puts the blue curve in a balanced condition. It possesses two almost equally high maxima, one at wave-length $\lambda = 550\,\mu\mu$, so in the maximum sensitiveness of the cone curve, the other at $\lambda = 440\,\mu\mu$, and symmetrically between at $\lambda = 495\,\mu\mu$ and so in the red complement a pronounced minimum. These peculiarities of the blue curve can on the vibration theory be expressed as a coupling of two damped resonators originally tuned to the same pitch. The disagreement of the uncoupled resonators falls then on the abscissa value of the ordinate minimum, so at $\lambda = 495\,\mu\mu$; there are thus the two uncoupled blue resonators in disagreement on the red complement. A further careful experimental investigation of the whole subject is recommended. J. J. S.

822. *The Ostwald Double-Colour Cone.* **O. Meissner.** (Zeits. f. Physik, 21. 1. pp. 68–72, 1924.)—According to Ostwald, every colour may be defined by 3 characteristics, *viz.*, the colour tone c (in the scale of 100 divisions, 0 = yellow, 25 = red, 50 = blue, etc.), the white content w and the black content s, from which the purity r, as a dependent variable is derived, where $r \equiv 100 - (w + s)$. The grey content is $w/(w + s)$. All derivatives of a definite pure colour form a colour triangle, and by its rotation about the grey axis there arises a double cone, the properties of which are mathematically described and by it the characteristics of a mixed colour determined from its components. It is shown that the purity of a composite colour is always lower than the arithmetic mean of the purities of the separate shades. An example is given for forming grey out of 3 colours. The paper is an interesting application of elementary mathematics to colour technology. H. H. Ho.

823. *Is Radiation One-Sided?* **G. Joos.** (Phys. Zeits. 24. pp. 469–472; Disc., 472–473, Nov. 1–15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—The Hertz solutions indicate symmetrical effects, so that the radiating atom would suffer no recoil; quantum emission would involve recoil. Experiments indicate the latter. Luminous phenomena, due to even a very small number of quanta, obey the laws of geometrical optics. A. D.

824. *Visibility of Radiant Energy.* **K. S. Gibson and E. P. T. Tyndall.** (Bureau of Standards, Sci. Papers No. 475. pp. 131–191, 1923.)—By the visibility of radiant energy is meant the ratio of luminosity to radiant power at the various wave-lengths in the spectrum. The American Bureau of Standards, in co-operation with the Nela Research Laboratories, has made a new determination of the visibility of radiant energy by the step-by-step method, an equality-of-brightness method with little or no hue difference in the two parts of the photometric field. Between 490 and 680 $m\mu$ inclusive, measurements were made upon 52 observers, some of them common to previous investigations. For 38 of these observers, measurements were continued to include 430 and 740 $m\mu$. Energy values were based upon radiometric and spectrophotometric measurements made at the bureau, checked by an independent colour temperature measurement at the Nela Research Laboratories. Luminosity values were obtained with a Brace spectrophotometer. The step was made by moving the collimator slit. The ratios of luminosities were measured with a Brodhun variable sector. The photometric field was the divided circle type subtending an angle of 3°. Brightnesses were safely above the Purkinje region, except perhaps at the ends of the spectrum. Detailed comparisons are made between the individual and average results of this investigation and those of previous investigations. There is no certain difference between the average values of visibility obtained by the flicker and equality-of-brightness methods provided the former is used under the experimental conditions recommended by Ives and the latter does not depart too widely from these conditions. A revision of the I.E.S. mean curve is proposed, which results in better agreement with the average experimental visibility data, and still gives the same wave-length centre of gravity for light of a colour temperature of 2077° K., as is given by Ives' physical photometer solution. It is considered that the step-by-step method of measuring visibility is a reliable method, with a precision comparable with that of the flicker method, and much superior to the simple equality-of-brightness method involving large hue differences. [See also Am. Illum. Eng. Soc., Trans. 19. pp. 176–193, Feb., 1924.] J. J. S.

825. *The Polarimeter and its Practical Applications.* **C. A. Skinner.** (Frank. Inst., J. 196. pp. 721–750, Dec., 1923.)—A review of some fundamental facts concerning polarised light is first given. The devices which serve as the polarisation elements of all instruments are then described, followed by a description of half-shade azimuth polarimeters, elliptic polarimeters, Tool's general polarimeter, and a universal polarimeter designed at the Bureau of Standards. The practical applications of polarimeters to saccharimetry, photometry, colorimetry, pyrometry, determination of the optical constants of absorbing media, mechanical stress analysis, and testing of the optical homogeneity of glass are briefly described. J. J. S.

826. *Rotatory Dispersion Method of Colorimetry and Heterochromatic Photometry.* **I. G. Priest.** (Am. Illum. Eng. Soc., Trans. 18. pp. 861–864; Disc., 864–868, Nov., 1923. Abstract.)—A general account of the principles and method of use of the rotatory dispersion photometer previously described [see Abstract 1127 (1922)]. The instrument is proposed as a solution of the visual photometry and colorimetry of all illuminants which give approximately black body or grey body radiation.

J. W. T. W.

827. *On Some Theories of Natural Rotatory Polarisation.* **H. Chipart.** (Comptes Rendus, 177. pp. 1213–1215, Dec. 3, 1923.)—The experimental results of Longchambon upon the rotatory power of biaxial crystals have necessitated a return to the study of the propagation of light in media destitute of a centre of symmetry. Accordingly a discussion of MacCullagh's work is first given, with many historical references, following which a comparison is made with the theories of Sarrau and Boussinesq. It is concluded that Boussinesq's equations should be adopted in preference to those of Sarrau and in conformity with the views of Green and MacCullagh the dielectric polarisation P is postulated as a linear vectorial function of E, $\frac{\partial E}{\partial x}, \frac{\partial E}{\partial y}, \frac{\partial E}{\partial z}$, from which the equation is derived:

$$P_x = \frac{\partial w}{\partial Ex} - \left(\frac{\partial}{\partial x} \frac{\partial w}{\partial \frac{\partial Ex}{\partial x}} + \frac{\partial}{\partial y} \frac{\partial w}{\partial \frac{\partial Ex}{\partial y}} + \frac{\partial}{\partial z} \cdot \frac{\partial w}{\partial \frac{\partial Ex}{\partial z}} \right)$$

H. H. Ho.

828. *Dispersion of Double Refraction in Crystals.* **C. Gaudefroy.** (Comptes Rendus, 177. pp. 1046–1048, Nov. 19, 1923.)—If a crystalline section illuminated by white light is arranged between crossed nicols so that the incident bundle is normal to the face of incidence, there will be seen at the face of emergence a chromatic scale which in general is near that of Newton. But this is not always the case. On comparing actual scales with that of Newton it is observed: (1) The total extension of the chromatic scales, that is, the number of orders covered by the tints from the edge up to the white of superior order, is variable. Certain scales are restricted, or shorter than that of Newton, others are more extended than usual. (2) The region of bright tints, which extends from the orange of the first order to the green of the third in Newton's scale, commences and ends nearer the edge in the restricted scales, farther from it in the extended ones. (3) The most extended scales show in the first orders fringes alternately white and dark almost achromatic, and in the last distinct orders fringes of complementary tints. Ammoniacal carbonate of silver shows more than 35 distinct orders with white light. (4) Calling direct the series of colours of the spectrum when the wave-length increases, most chromatic scales exhibit, like that of Newton, the direct series, but there are scales which exhibit the inverse series. To assimilate a tint of an inverse series to an analogous tint on Newton's scale would lead to errors in the optical sign, since the series of tints called rising in Newton's scale is descending in the other.

These observations can be foreseen by a general study of the dispersion of double refractivity. If it is agreed that the white of higher order appears on different sections at points where the same number of radiations are extinguished in the emergent bundle, the relative extension, ϵ, of a scale may be calculated, that is the ratio of its extension to that of Newton's scale, by the equation $\epsilon = 1/\lambda_j(\Phi'_j)$ where λ_j is the geometric mean between the extreme red and violet wave-lengths, $\lambda_j = \sqrt{\lambda_R \lambda_V}$, and $\Phi' = (n'_1 - n'_2)/(n_1 - n_2) - 1/\lambda$, $n_1 - n_2$ being the double refractivity and $n'_1 - n'_2$ its derivative. Φ'_j is the particular value that Φ' takes in the neighbourhood of wave-length λ_j the middle yellow. This expression ϵ of the extension is only approximate, and is only legitimate when Φ' does not pass through the values zero or infinity. By this formula is found for quartz $\epsilon = 0{\cdot}90$; for calcite $\epsilon = 0{\cdot}83$. J. J. S.

829. *Variations of the Dispersion of Double Refraction in the Same Crystal.* **C. Gaudefroy.** (Comptes Rendus, 177. pp. 1227–1229, Dec. 3, 1923.)—The object of this note is to show that sections cut in the same crystal along different orientations do not give in general the same chromatic scale [see preceding Abstract] when they are illuminated with parallel light between crossed nicols. This can be observed by an approximate method by causing a section placed between crossed nicols to turn around any straight line, then successive different scales are seen which resemble approximately those which would be observed with sections cut along different orientations and correctly placed, that is in such a manner that the normal ON to the face of entrance of the light is parallel to the incident rays. Another approximate method is the examination of certain peculiarities in the coloured rings observed in convergent light on a plate with parallel faces. These properties can be foreseen by calculation of the variations of the function $\Phi' = (n'_1 - n'_2)/(n_1 - n_2) - 1/\lambda$ with the direction ON normal to the refracted waves. Thus it may be shown that in a uniaxial crystal the function Φ' remains constant when the direction ON varies; consequently the scale there remains invariable. In a biaxial crystal the function Φ' relative to a given wave-length passes through all values from $-\infty$ to $+\infty$: consequently the scales pass through all the extensions possible. If a radius vector equal to Φ' is placed along ON the locus of the extremities is a surface such that: (1) Each definite value c of the function Φ' is represented by a curve C which passes through the four poles of the optic axes A.C.I. (axes of internal conical refraction) in forming two or four closed rings. In particular a curve $\Phi'_j = c$, relative to the wave-length of the middle yellow, is the locus of the directions ON corresponding to scales of the same extension. (2) If ON starting from the direction of an optic axis turns round an octant defined by n_g, n_m, n_p, ON traverses curves $\Phi'_j = c$, where c increases (or decreases) continuously from $-\infty$ to $+\infty$. Consequently the corresponding scales vary from the most restricted direct scales to the most restricted inverse ones, passing through a scale almost achromatic. The most remarkable curves are $\Phi'_j = -1/\lambda_j$, which corresponds to an extension equal to Newton's scale; and $\Phi'_j = 0$, which corresponds to scales almost achromatic. To the optical properties which serve to characterise crystalline species may be added: the position of the rings nearly achromatic, and of their intersection with the principal optic planes; the extensions of the three principal chromatic scales; and the three values of Φ'_j relative to the three principal optic planes. **Erratum** (Ibid., p. 1452, Dec. 26, 1923). J. J. S.

830. *Crossed Michelson Gratings.* **Rita Brunetti.** (Accad. Lincei, Atti, 32. ii. pp. 286–289, Nov. 10, 1923.)—Note, practical and mathematical, on the use of crossed Michelson gratings to discriminate the order of a secondary radiation. The law of distribution of interference-images is then not the same as the law of dispersion of radiations in their spectrum. A. D.

831. *Behaviour of Silver Bromide to Rays of Short Wave-Length.* **T. Thorne-Baker.** (Faraday Soc., Trans. 19. pp. 335–339, Nov., 1923.)—The photographic method of recording is used so largely and on such an increasing scale in various types of physical measurement, that the peculiarity of the sensitive plate deserves some attention. The object of this paper is not so much to deal with particular facts as to emphasise this need. Experiments in the Imperial Co.'s laboratory have shown that an emulsion made of pure silver bromide, prepared throughout with distilled water and made with ashless gelatin, possesses a sensitiveness which extends less toward both the extreme ultra-violet and the visible blue than a similar emulsion made under ordinary conditions and containing silver iodide. As the result of experiments still in progress, it would appear that by using monochromatic X-rays (or more correctly a single line filtered from an X-ray spectrum), there can be obtained a real method of sensitometrically testing an X-ray plate, or alternately of employing a photographic method of measuring X-ray dosage in medical therapy. A. E. G.

832. *Studies in Solarisation.* **H. Scheffers.** (Zeits. f. Physik, 20. 2. pp. 109–128, 1923.)—Exposure of a series of photographic plates to progressively brighter illumination shows a change in darkening which may be expressed by a curve. This curve at first rises steeply, then becomes almost flat, finally descends; and the descent represents what is known as solarisation or reversal. Various attempts have been made to explain this phenomenon, but all can be shown to be unsuccessful. A solution is now offered, following the demonstration by Eggert and Noddack that the quantum theory and Einstein's law of equivalents apply to photographic plates.

A number of experiments are described which prove that solarisation does not depend upon the kind of light, or plate, or developer used; but that it can be delayed in various ways, by diluting the developer, or bathing the plates after exposure in very dilute fixing salts, or treating them with saltpetre; and it can be hastened by warming the plates during or after exposure, or by adding colloidal silver to the silver bromide when preparing them. A quantitative determination of the darkening-curve was obtained by exposing a number of plates to progressively brighter illumination, after which they were developed and fixed, and the differences were computed by: (1) Estimating the density of each, (2) removing and measuring the amount of silver on each, and (3) counting under the microscope the number of silver grains per square centimetre on each. The result shows that with increased darkening the density and the amount of silver both increase in the same proportion, until the point of solarisation, when both fall off equally; but that the number of silver grains, which also increases up to the point of solarisation, remains nearly constant after this. The grains must therefore be smaller on the solarised plates, and this is apparent also under the microscope, a large number being small and grey instead of large, black, and fully developed. The conclusion reached is that solarisation is a problem of development. The amount of silver in the latent image increases in proportion to the intensity of the light, one atom of Ag being formed to each quantum; and these atoms act as catalysers in the process of development of the plates. But in the solarised grains, which contain a very large number of silver atoms, these coagulate through their mutual attractions, hence the active surface of the silver is diminished, its catalysing effect is lessened, and development is hindered.

This theory explains all the results of the experiments, and makes clear why solarisation is hindered by peptonising agents and hastened by coagulating agents. M. A. E.

833. *Statistical Equilibrium in Relation to the Photoelectric Effect, and its Application to the Determination of Absorption Coefficients.* **E. A. Milne.** (Phil. Mag. 47. pp. 209–241, Jan., 1924.)—This paper is concerned with the evaluation of the absolute values of optical absorption coefficients, the word "optical" being understood in reference to the outer levels of an atom, though for highly ionised atoms the corresponding frequencies may lie in the X-ray region. The absolute values of monochromatic optical absorption coefficients for neutral or once-ionised atoms appear to be of the order of magnitude of 10^9, but little is known concerning them either experimentally or theoretically. A method of calculating them, however, has been furnished by Einstein's discussion of the thermodynamic equilibrium subsisting between a gas and black radiation in an enclosure. This provides a relation between the absorption coefficient and the mean time of occupancy of an outer orbit, the order of magnitude of which is known experimentally. It is shown, however, that the relation involves the unknown theoretical width of the "monochromatic" line, and is therefore not available for precise estimates although providing confirmation of the order of magnitude of the absorption coefficients. Einstein's method can be applied to any condition of equilibrium to determine a relation between the reaction-velocities of the opposing processes, and it is now so applied to obtain the relation between photoelectric ionisation and the probability of electron-capture by an ion, considering the equilibrium subsisting between atoms, ions, electrons, and radiation in an enclosure. For strict thermodynamic equilibrium it is found necessary to assume that electron-capture can be stimulated by external radiation. The relation found evaluates the absorption coefficient for the region of continuous absorption lying on the high-frequency side of the limit of an optical series, in terms of the capture-probability function. It is shown that for small speeds the probability of capture must vary inversely as the square of the velocity, and, in so far as this holds exactly, the absorption coefficient beyond the series limit will vary as the inverse square of the frequency. The capture law used by Eddington for the interior of a star, where the mean absorption coefficient is of the order of 40 and the frequencies are in the X-ray region is an inverse square law. Applied to hydrogen, calcium, and mercury by means of the formulæ obtained in the paper, it furnishes absorption coefficients in the optical region for the continuous spectrum beyond a series limit which are in agreement with the estimates given in the monochromatic absorption coefficients. This gives some confirmation of the inverse square law over a considerable range of velocities; it may be considered as linking up the physics of the interior of a star, the physics of stellar atmospheres, and the physics of the atom. The mean life of a hydrogen atom in the 2-quantum state, under the conditions of a typical stellar atmosphere, is shown to be about 10^{-8} sec., as limited by the process of photoelectric ionisation. The mean absorption coefficient for a highly ionised gas at high temperatures has been determined, and differs from the value from Eddington's formula by a factor depending on the relevant ionisation potentials. The order of magnitude of these has been determined as a function of pressure and temperature, and it is shown that under typical conditions in the interior of a star, atoms of ion will have lost their L-electrons but will mostly retain their two K-electrons. The validity of the method and of the resulting formulæ is shown to be entirely independent of the extent to which ionisation occurs by collision.

H. H. Ho.

834. *Topochemistry of Development and Sensitising Nuclei.* **S. E. Sheppard, E. P. Wightman, and A. P. H. Trivelli.** (Eastman Kodak Co. Research Lab. Comm. No. 190. Frank. Inst., J. 196. pp. 653–673, Nov., and pp. 779–802, Dec., 1923.)—The term "topochemistry" in reference to the silver halide grains of photographic emulsions, embraces effects which can be related to the position of a component in the grain, and refers principally to distinctions between effects on the outside (surface) and the inside of the grain. While many workers have made use of "topochemical" considerations in dealing with the photographic emulsion, it is Lüppo-Cramer who has made the most numerous, as also the most varied and ingenious, applications of this conception. In the first of these two papers the following points are dealt with: Effect of iodide and nucleus exposure; the Lainer effect, *i.e.* acceleration of development for certain developers; nucleus exposure and oxidising treatments; fogging action of potassium iodide baths; potassium iodide treatment and the regeneration of latent image; the retention of chromic acid and chromium salts by gelatino-silver bromide emulsion, *e.g.* absorption of CrO_3 to precipitated AgBr, retention of CrO_3 by gelatin, possible effects of CrO_3 on the AgBr emulsion and the treatment used practically for removal of CrO_3; destruction of sensitivity and regeneration. A table is given showing the action of CrO_3 and KI on the latent image in a Graflex plate, exposed 20 secs. to standard light, developed 4 mins. In the second paper destruction and regeneration of latent image and the effect of KI is treated in two sections: (1) Physical development before fixation and chemical development; (2) physical development after fixation. Tables showing the action of CrO_3 and KI on the latent image, the action of persulphate on latent image and sensitivity are given. The continuity of sensitivity, the latent image, the solarised latent image, and the visible image are next considered; then the influence of oxidisers on the sensitivity with one-grain layers is dealt with as follows: relation of CrO_3 desensitising to size of grain; densitometry; action of chromic acid and iodide on one-grain layers. This section is illustrated graphically and tables of results are given. Photographic reproductions of seed Graflex plates before and after removal of Ag are given. This work is regarded by the authors as substantiating Lüppo-Cramer's "Keimblosslegung" theory so far as relatively strong iodide solutions are concerned, but consider that with the very dilute solutions adsorption effects are more important. A. E. G.

835. *Test of a Theory of Radiation.* **G. P. Thomson.** (Roy. Soc., Proc. 104. pp. 115–120, Aug. 1, 1923.)—The author tests the hypothesis recently used by Silberstein [Abstract 2270 (1922)] who regarded the energy of radiation as concentrated in a few rays, "light darts." The author examines the light emitted by positive rays showing the Doppler effect. The light is made to pass through two slits so arranged that the emitting particle is, for only a short portion of its path, sending light through both slits. The time taken to traverse this portion of its path is made less than the time taken to emit a complete light dart. It is thus necessary to fix a lower limit to the length of light darts for the line used, H_β. "Since the various atoms emitting quanta in a source are in no necessary phase relation, interference can only occur over a path difference not greater than the length of the train of waves corresponding to the emission of a quantum, *i.e.* to the length of a light dart." This length is calculated by using Gehrcke and Lau's value for the observed half-width of the components of the line. It is found that the light received from the source shows the usual visual and photographic properties when the train of waves is shorter than that produced in the emission of a quantum of light.

T. H.

836. *Molecular Spectra and Half-Quanta.* **E. F. Barker.** (Astrophys. J. 58. pp. 201–207, Nov., 1923.)—Half-quantum numbers designating steady states of molecular rotation have been introduced in several recent discussions of band series. Only integral transitions are considered but the lowest steady state is assigned one half-quantum of angular momentum. This minimum may be due to the coupling between molecular and electronic rotations. An effect analogous to the Stark effect for line spectra has been shown by Hettner to depend upon the proper choice of quantum numbers for the band series and is suggested as a criterion for distinguishing between integral and half-quantum values. The general modification of the spectrum is of the second order and cannot be observed, but assuming integral numbers one line should show a first order effect. An absorption cell containing HCl between plates of platinised quartz 1 cm. apart was subjected to a field giving a spark across a gap of 8 mm. in air between 1-inch balls. No change in the absorption spectrum was detected. The hypothesis of half-quanta is supported by this experiment. Other facts tending towards support are the single missing line at the band centre for HCl and the position of the zero branch for CH_4.

J. J. S.

837. *Molecule-Structure and Absorption Spectra in Vapours.* **V. Henri.** (Comptes Rendus, 177. pp. 1037–1040, Nov. 19, 1923.)—During absorption, the energy of a molecule is raised, say from E_0 to E', the active or sensitised or critical energy. If the absorption be by quanta, the frequency ν is absorbed, where $\nu = (E' - E_0)/h$. The activation of a molecule is effected: (*a*) by changing the movement of electrons, (*b*) by changing the movement of atoms or groups of atoms, or (*c*) by affecting or inducing molecular rotation. Under (*a*) the change is always by quanta; the lowest amount is 334,000 *ca* per atom-gramme, so that λ is less than 9500 Å., and electronic absorption of energy is in the visible and the ultra-violet. Under (*b*), the change may be continuous or may be quantic as in heteropolar molecules; the bands are in the mean infra-red. Under (*c*) the change may be continuous or quantic; if quantic, the bands are in the extreme infra-red. The combination of these three enables three types to be set up: (1) (*a*), (*b*), and (*c*); (2) (*a*) and (*b*) only; (3) (*a*) only. Under the last of these the absorption spectrum consists of a number of broad bands, perfectly continuous; under (2), several groups, each group consisting of a number of narrow bands, each perfectly continuous; under (1), several groups, each group consisting of one or more series of bands, each band breaking up into one or several series of fine lines very near one another. A. D.

838. *Intensity Measurements of Spectral Lines.* **J. K. Robertson.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 983–995, Nov., 1923.)—Accurate intensity measurements of spectral lines have been very limited in number. For the most part quantitative use of the permanent record given by a spectrogram has been adopted in two different ways: (1) By using the neutral-tinted glass wedge method of Merton and Nicholson; (2) by measuring the density of the photographic image, that is, the degree of blackening on the plate. The author gives an account of preliminary tests of the relative advantages of the two methods. The essential feature of the wedge method consists in the use of a wedge of neutral-tinted glass placed immediately before the slit of the spectrograph. In consequence the more intense a line the longer it is on the plate. The numbers found by this method give within a few per cent. the actual number of times the intensity has changed. Subjectively the method is admirable, and although photographic, is independent of the time of development, but errors may arise from a variety of causes. The essence of the second method consists: (1) In the measurement of the degree of blackening, or the density of the image of a spectral line on the original negative; (2) in the use of an " H " and " D " curve to obtain the intensity change corresponding to each blackening or density change. To measure densities use was made of the microphotometer described by Meggers and Foote. This method is only of use for densities which fall on the straight portion of an H and D curve, and even then there are certain disadvantages. On the other hand in the microphotometer method readings are taken direct from the original negative. Subjectively, however, the advantages seem all to be on the side of the wedge method. As it is desirable to eliminate the subjective element as far as possible, the wedge method on the whole seems preferable. J. J. S.

839. *Ionisation and Resonance Phenomena.* **C. B. Bazzoni.** (Frank. Inst., J. 196. pp. 627–651, Nov., 1923.)—The present paper deals with certain subjects concerning the interaction of radiation and matter, but mainly with the interpretation of the theories of spectrum production and absorption. At the outset a brief summary is given of Bohr's theory of atomic structure and the mechanism of radiation. The formulæ derived from Balmer's formula for exhibiting the relations of the lines in spectra are next considered. A discussion then follows of the methods found by which measurable quantities of energy can be imparted to atomic systems, *viz.*: (1) By striking the atoms with electrons which have fallen through a known difference of electrical potential and have therefore a known energy, and (2) by allowing radiant energy of known frequence, made up of quanta of known magnitude, to fall on the atoms. The former gives the most direct proof of the Bohr idea, and the one most free from theoretical elements. Next comes a brief consideration of methods involving electronic impacts which have been used experimentally to determine these energy values. To study the results obtained with the devices described, attention is first devoted to mercury-vapour, then to helium. The latter is treated at some length, and it is stated that impact investigations have explained in a general way the optical series of helium and that unquestionably helium atoms possess above their fundamental orbits certain metastable states with different electronic configurations. The final topic considered is the stimulation of spectral lines by the absorption of radiant energy, Fuchtbauer's researches being very fully described. The paper is written in very clear and readable style and summarises concisely the present state of the subject. H. H. Ho.

840. *The Electrical Decomposition of Spectral Lines.* **A. Carrelli.** (N. Cimento, 25. pp. 213–229, May–June, 1923.)—A review of recent theoretical and experimental work on this subject. It may be said that as the study of the Zeeman effect has been decisive for the electronic theory, so the study of the Stark effect may be regarded as essentially connected with the quantum theory. J. J. S.

841. *Relations between "Raies Ultimes" and Resonance Lines.* **F. Croze.** (Comptes Rendus, 177. pp. 1285–1287, Dec. 10, 1923.)—The resonance lines of the emission spectrum of an element, the "raies ultimes," and the characteristic absorption lines are considered as identical by many writers. The author points out that this is not the case for elements possessing several series systems. *E.g.* in the spectra of elements of column II of the periodic table are a singlet system having a principal series $1S - mP$, and a triplet system having a principal series $1s - mp_i$ $(i = 1, 2, 3)$. In these elements, the resonance line is $1S - 2p_2$, corresponding to the passage of an electron from orbit $2p_2$ to orbit 1S, the normal orbit. This is because in these elements, the orbit $2p_2$ is least above the 1S in regard to energy level. But the "raie ultime," which is here also the characteristic line in the absorption spectrum of the vapour, is $1S - 2P$, notwithstanding that the orbit 2P has a higher energy level than has $2p_2$. It is generalised from this that the passage of an electron is easier between orbits whose terms belong to the same series system. This is confirmed by the work of Catalàn and of Kiess on the spectra of Cr, Mo, and Mn. [See Abstracts 2170 (1923) and 272 (1924).] A. C. M.

842. *Determination of the Schwarzschild Constant.* **J. K. Robertson.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 996–998, Nov., 1923.)—As a result of an investigation on the way in which the density of a photographic image varied with changing exposure, Schwarzschild enunciated the law that the product $It^{0·86}$ was constant. The author uses the Merton and Nicholson wedge method of measuring intensities of spectral lines to evaluate p the Schwarzschild blackening constant, and test the truth of the law. It is found that for the intensities used the Schwarzschild value of p is not far out, and that an extended investigation of the possible variations in its value with the wave-length would be worth while by the method used. J. J. S.

843. *Summary of Investigations in the Infra-Red Spectrum of Long Wave-Lengths.* **W. Weniger.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 517–527, July, 1923.)—This paper is a brief summary of the methods employed and the results obtained by various workers before 1922 in the study of the spectral region included in the wave-length interval $50\,\mu$ to $300\,\mu$. Full tables are given (collected from the 22 papers to which reference is made) of (1) the wave-lengths of residual rays from various susbtances, (2) the transmission of quartz; the values given are for unpolarised light uncorrected for reflection, (3) the transmission of radiation through various substances, uncorrected for reflection, (4) the transmission of black paper and lamp black, (5) the reflection factors for various substances, and (6) the reflection and transmission factors for a number of crystals mostly with polarised radiation. T. H.

844. *Method for Weak Absorption-Lines.* **W. Schütz.** (Phys. Zeits. 24. pp. 459–460, Nov. 1–15, 1923.)—A method for observing weak absorption-lines in the vapour of metals, based upon rotation of the plane of polarisation by a magnetic field in the neighbourhood of a band. The absorption-band comes out as a bright band against a dark background. Applicable to metallic vapours of extreme tenuity. A. D.

845. *The Ultra-Violet End of the Solar Spectrum.* **R. Dietzius.** (Meteorolog. Zeits. 40. pp. 297–301, Oct., 1923.)—A discussion of various researches on the absorption effect of ozone in the earth's atmosphere.

J. J. S.

846. *Fluorescence Spectra. Part I. Benzenoid Hydrocarbon Vapours.* **J. K. Marsh.** (Chem. Soc., J. 123. pp. 3315–3324, Dec., 1923.)—The fluorescence spectra of various benzene and similar hydrocarbon vapours have been photographed, stimulating the vapours contained in a small quartz cell with light from a Kromeyer mercury lamp. The outer surrounding vessel was blackened to avoid stray light, but traces of mercury lines are visible in the photographs, and blank exposures were taken in juxtaposition to allow for this. A heating element was employed to vaporise liquids of relatively high boiling-point. Observations were made at pressures of 12–15 mm., using a water-pump; the results are regarded as qualitative only, owing to some of the governing factors being subject to uncontrollable variation; *e.g.* the slit could not be regarded as constant, owing to expansion of the jaws at different temperatures; also a yellow film formed on the inside of the observation cell, and this film was very opaque to ultra-violet light; this necessitated frequent cleaning.

Benzene, toluene, ethylbenzene, *o*-xylene, mesitylene, styrene, and phenylacetylene vapours were investigated. The spectrum is described for each substance; they are more complicated than when observed in solution. A regular rise and fall in intensity may be traced throughout the series, which is attributed to the common possession of a benzene nucleus. Where they overlap, the vapour absorption and fluorescence bands are identical. A. C. M.

847. *Hydrogen Secondary Spectrum, and Note on the Continuous Spectrum.* **E. Gehrcke** and **E. Lau.** (Preuss. Akad. Wiss. Berlin, Ber. 24. pp. 242–252, 1923. From the Reichsanstalt.)—A hot kathode hydrogen tube was employed, using as kathode the incandescent spot of lime on a Wehnelt kathode. Under these circumstances the Fulcher bands were found to be intensified. The authors find that the red and green bands are intensified when slow kathode rays are used, contrary to the behaviour of the rest of the secondary spectrum as far as has been observed. The red, green, and blue bands are discussed in detail, with reference to the potentials required and the intensities of the lines in the bands. The remainder of the lines are then discussed. A symmetrical group is found, λλ5836–5760, with a "centre" at 5799·25. There is also a pair of groups, called "X" and "Y" groups, which have a constant wave-length difference between corresponding numbers of the two groups. These are λλ6090–6021 and λλ6003–5932, with a wave-length difference of 88 Å. approximately.

In a brief note the conditions necessary to excite the continuous spectrum between λλ3600 and 2300 are shown to be the same as for the secondary spectrum.

The excitation of the bands is attributed to the direct action of "primary" electrons, or of "secondary" electrons emitted by molecules of hydrogen. In any case, the authors' results show that the different lines of the bands are all excited by the same electron-velocity, or at any rate by electron-velocities lying within a narrow range. So it is to be concluded that a single line in one of the bands does not absorb all the energy of a particular electron, but that this quantity of energy is "shared out" among the lines.

For small electron-velocities the primary spectrum is weakened, while the Fulcher bands are intensified, and *vice versa*. It is therefore concluded that when a colliding electron has sufficient energy it will split the molecule. When the energy of the colliding electron is insufficient, it will suffice merely to move the two protons apart a little, the mutual separation depending upon the energy. If the energy falls below 12 volts, then no such mutual displacement of the protons is possible. The remainder of the spectrum is attributed to carriers other than the normal atom and molecule; positively and negatively charged molecules are suggested, and carriers such as H_3, H_4. As for the continuous spectrum, it is found by these investigators to occur under the same conditions as the Fulcher bands; this conflicts with astrophysical evidence, etc., if it is taken to be the same continuous spectrum as that associated usually with the Balmer series.

It is therefore concluded that we have here to deal with a differently excited continuous spectrum. [See Abstract 906 (1923).] A. C. M.

848. *Absorption Spectra of Some Metallic Vapours.* **W. Grotrian.** (Zeits. f. Physik, 18. 3–4. pp. 169–182, 1923.)—A continuation of earlier work, when thallium and indium vapours were studied [see Abstract 907 (1923)]. The experimental arrangements were unaltered; the observation tube was made of opaque quartz, with the exception of clear end-windows, which were fused on. The temperature was measured with a platinum-platinum-indium thermoelement; and the absorption spectra of different metallic vapours at differing temperatures were thus investigated. The spectrum of the light employed as source was continuous, down to about λ2350.

Copper.—Absorption of the first principal doublet λλ3274 and 3247 is observed above 1050° C.

Silver.—λλ3283, 3382 absorbed above 900° C.

Gallium.—Absorption of subordinate series lines originating in the term $2p_2$ observed above 850°, and from the term $2p_1$ above 900°.

Lead.—Absorption of λ2833 started at 550°, and broadened as the temperature rose into a wide band. This is attributed to molecule-formation, and the wide band is looked on as the absorption-band of the molecule. This line is identified in Thorsen's series-system, and gives an ionisation potential of 7·38 volts for lead.

Zinc gives, above 1050° C., absorption lines at λλ3009·2, 2863·4, and 2706·6.

Bismuth has a typical absorption-line λ3067 visible above 650° C. At higher temperatures strong bands become visible, showing that bismuth vapour is probably polyatomic.

Antimony shows bands and strong continuous absorption.

Manganese.—Two triplets are observed above 850° C., which one would expect to be reversed from consideration of Catalàn's series. These are λλ2794·82, 2798·27, 2801·07, and λλ4030·76, 4033·07, and 4034·49.

A. C. M.

849. *Spectra of Fifth-Group Metals.* **A. E. Ruark, F. L. Mohler, P. D. Foote, and R. L. Chenault.** (Nature, 112. p. 831, Dec. 8, 1923.)—The absorption spectrum of Bi and the spectrum of the thermionic discharge have been photographed for potentials from 4 to 60 volts. Several stages have been found in excitation of the arc spectrum, and at least two classes of spark lines; 64 arc lines have been classified. The spectrum of the neutral atom is characterised by wide doublets, most of the energy levels being of the *p* type. Inelastic collisions take place at about 2 and about 4 volts, ionisation at about 8 volts, though it is difficult to separate critical potentials above 5 volts. The first spark spectrum appears near 14 volts. The absorption spectrum at about 800° C. shows lines due to the atom, and also some new bands. The lines all arise from the lowest energy level. Additional classifications have also been found in the arsenic spectrum. A range of 38,000 cm.$^{-1}$ and another of 32,000 cm.$^{-1}$ contains no energy levels. The previously given resonance potential corresponds to the mean of the wave numbers of the "raies ultimes." From evidence from the classification, the ionisation potential must be greater than 10·6 volts, while the experimental value is 11·5 volts.

A. C. M.

850. *The Iodine Spectrum and the Band Spectrum of Mercury.* **W. Gerlach.** (Phys. Zeits. 24. pp. 467–469; Disc., 469, Nov. 1–15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—A general account of the iodine spectrum. The author emphasises the importance of the Bohr theory with respect to line spectra and also the band spectra associated with molecules. A continuous spectrum may, according to the quantum theory, be produced by the continuous variation of a "term," for instance, by the continuous series of energy-states which may be assumed by a free electron. A second possibility has been pointed out by J. Franck, *i.e.* the application of the same ideas as involved in the binding of an electron and a positive ion, to the formation of a negative ion by the addition of an electron to an electronegative atom. The author has in another paper [Abstract 516 (1924)] described the "electron affinity spectrum" of iodine under various conditions of pressure and temperature, and the implication of its short range is discussed. It is now considered certain that the band at 4800 is not due to the iodine atom, since in contrast to 3460 it diminishes in heated vapour. The rise and the maximum at 4800 is to be ascribed to the electron affinity spectrum of the electronegative iodine molecules and the continuous spectrum which follows to the excited iodine molecules. Finally the emission due to electrically excited mercury-vapour is mentioned. The radiation corresponds closely to the iodine emission and has band and continuous regions. It is not certain that this corresponds to a Hg_2-molecule, but the bands are to be ascribed to a Na-Hg molecule. Hg_2-molecules are responsible for a number of bands which behave in a very similar way to the iodine bands, and which group themselves in a characteristic way with respect to the principal lines of the mercury spectrum.

Discussion.—**Steubing** referred to the difficulties of photographic methods in determining the limits of bands. **Born**: From a theoretical standpoint it might be expected that two electron affinity spectra should be obtainable. The halogen atom has an outer shell of seven electrons, of which three had circular and four elliptical orbits, or *vice versa*; there are therefore two kinds of atoms analogous to the two types of rare gaseous ions which manifested themselves in the L-doublets. Both types of atoms attempt to catch electrons and both will, when excited, produce "electron affinity spectra" which are not identical, owing to the small energy differences of the two types of atoms. **Gerlach** replied that if the 4800 is to be ascribed to another atom the results show that the negative ionisation of this atom at higher temperatures is more improbable that for the 3460-atoms. W. V. M.

851. *Higher Spark-Spectra of Mercury.* **L.** and **E. Bloch.** (J. de Physique et le Radium, 4. pp. 333–348, Oct., 1923.)—The authors have previously shown [Abstract 1384 (1923)] that in an electrodeless discharge, as the voltage is increased the luminosity in the tube goes through progressive stages. The outer edge of the ring shows first the arc spectrum, then the first spark, second spark, and so on as the voltage is increased, the spectra of lower order going towards the centre of the tube as higher-order spectra are excited. This is now applied to the case of mercury, and a table of lines belonging to this element is given, in which the order of the spectrum is given for each line. Important differences occur between some of these results and Stark's conclusions based on positive-ray observations. The voltage is controlled by widening a spark-gap; it is claimed for this method that other factors, especially frequency, are unaltered, as is not the case when inductances are inserted. A. C. M.

852. *Spectral Lines of Ionised Potassium and Argon.* **H. W. J. Dik** and **P. Zeeman.** (K. Akad. Amsterdam, Proc. 26. 7–8. pp. 498–503, 1923.)—Tables of potassium lines on discharge without electrodes. [See Abstracts 2278 (1922) and 95 (1924).] A. D.

853. *Band Spectrum of Copper.* **R. Frerichs.** (Zeits. f. Physik, 20. 3–4. pp. 170–187, 1923.)—The paper concerns the structure and intensities of the copper band spectrum and is a continuation of a series of papers by Heurlinger, Kratzer, and Hulthén. [See Abstracts 893 (1919) and 1600 (1922).]

The paper does not admit of satisfactory abstraction as it is largely composed of tables of wave-lengths and frequencies referred to the international values for the iron spectrum (Burns Lick Observatory Bulletin, No. 247, 1913), the results being reduced to vacuo. A system of energy levels is given corresponding to the experimental investigation, and various terms discussed. The author calculates the moment of inertia of the molecules involved in the production of the copper band spectrum as $0\cdot35\ 10^{-39}$ g.cm.^{2} This remarkably small value leads to the surmise that compounds with hydrogen are involved, or that the vapour behaves as almost entirely monatomic. The question has been investigated and the presence of hydrogen in a free or combined form is necessary, particularly in the case of the bands for zinc, which do not appear in oxygen and dry air, but are very strong in an atmosphere of water-vapour. The effect of hydrogen is not, however, completely understood and similarly those of the various isotopes in causing splitting of the bands, copper not being a simple element. W. V. M.

854. *Relations in the Band Spectra of Copper.* **E. Bengtsson.** (Zeits. f. Physik, 20. 3–4. pp. 229–236, 1923.)—Copper chloride was introduced into the air-coal-gas flame and photographed with a Rowland concave-grating. The bands were measured, and are accurate to ± 0·1 frequency-unit. The lines of each band fall into two series. The bands λλ4280, 4005, and 3777 belong to the same final-state of the molecule; while the bands 4280 and 4649, and 4005 and 4689 belong to the same initial condition of the molecule. A scheme of levels is given, into which fits also Hartley's weak band. The null-lines of the bands can be expressed by a general formula. A. C. M.

855. *Extension of Tin and Zinc Spark Spectra in the Schumann Region.* **L. and E. Bloch.** (Comptes Rendus, 177. pp. 1025–1028, Nov. 19, 1923.)—Improvements have been made in the fluorite vacuum spectrograph previously described, and the range of spectrum extended by passing the spark in nitrogen instead of in hydrogen. The tin spectrum has been compared with the hydrogen spectrum as measured by Lyman and has been used as a secondary standard for other substances. Tables of wave-lengths of 84 tin lines and 107 zinc lines are given. An accuracy of 0·1 Å. is claimed. F. S.

856. *Regularities in the Arc Spectrum of Vanadium.* **W. F. Meggers.** (Washington Acad. Sci., J. 13. pp. 317–325, Aug. 19, 1923.)—Kossel and Sommerfeld proposed the spectroscopic "displacement law" which states that the spark spectrum of any chemical element resembles in structure the arc spectrum of the element preceding it in the periodic system. This led to the "alternation law" that the even and odd structures of both arc and spark spectra alternate between adjacent columns of the periodic classification. In recent years sufficient information has been obtained to test the alternation law for all the columns of the periodic table except V. In this paper some examples of the regularities in the arc spectrum of vanadium are given. It is claimed that vanadium falls into the general scheme predicted and it can be stated positively that the alternation law is verified for the arc spectra across the entire table of chemical elements. To test the displacement law further study of spark spectra is required. T. H.

857. *The Arrangement of Vanadium Lines in Multiplets.* **O. Laporte.** (Phys. Zeits. 24. pp. 510–515, Dec. 15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—A short discussion of the relative multiplicity of the spectra of Cr and Mn in comparison with the alkalis and alkaline earths shows that the old Rydberg rule with respect to variation of multiplicity with the column of the periodic table in which the element occurs is confirmed; thus Mn in the 7th column has an octet system, Cr in the 6th column a septet system, and so on. In order to test this rule and fill the gap between Sc and Cr, the vanadium spectrum has been investigated. It is shown that a quartet system appears in which two groups of terms occur, distinguished as "dashed" and "undashed" symbols; but for vanadium, combination between these terms appears to contradict the selection principle for azimuthal quantum numbers. The multiplets occur partially as a quartet, partially as a sextet system, as well as in intercombination between them.

By means of two series of the type $d - np$ an approximate determination of the term values is made. The appearance of widely separated "Uber-" Bergmann F^* terms in the vanadium spectrum was proved by a multiplet which must be explained as an FF^* combination. W. V. M.

858. *The Direct Geometrical Determination of the Wave-Length of X-Rays.* **L. Puccianti.** (N. Cimento, 25. pp. 307–309, May–June, 1923.)—From the paper of A. H. Compton on total reflection of X-rays [Abstract 2198 (1923)] the author is led to suggest that this phenomenon might be used to obtain the direct geometrical measurement of the wave-length of these rays. If a fine pencil of X-rays fall at almost grazing incidence on a plane sheet striated perpendicularly to the plane of incidence so as to form an ordinary diffraction grating, the ray regularly reflected will be accompanied by diffracted rays which notwithstanding the very small wave-length will have an appreciable separation, because in such conditions the grating, although not very fine will act as equivalent to a grating very much more finely ruled than could be constructed and worked with. If α is the angle which the ray makes with the plane of the grating and β_K the angle that the diffracted ray of order K makes with the plane of the grating then $\cos \alpha - \cos \beta_K = \pm K\lambda/p$ where p is the period of the grating and λ the wave-length. Thus approximately $\beta_K^2 = \alpha^2 \pm 2K\lambda/p$ where K is always positive and the sign $+$ holds for the more inclined diffracted rays, the sign $-$ for the less inclined of the ray regularly reflected, with respect to the plane of the grating. Putting $p = 2 \cdot 10^{-8}$, $\lambda = 10^{-8}$, $K = 1$, and calculating the two values of β_1 for some incidences numbers are got which show the possibility of making the measurement. J. J. S.

859. *The Geiger Counter as a Sensitive Detector of X-Radiation.* **H. Behnken, G. Jaeckel** and **W. Kutzner.** (Zeits. f. Physik, 20. 3–4. pp. 188–190, 1923.)—H. Geiger [Abstract 1873 (1913)] has shown that a fine wire when negatively charged with respect to its surroundings may be used for counting β-rays, and since these β-rays are rapidly moving electrons and such electrons are emitted under the action of X-rays, the arrangement due to Geiger may be used for the detection of X-radiation if the released electrons can pass near the sensitive region. This is, of course, always the case if the X-rays fall directly on to the counter, freeing electrons from the point, the wall of the chamber and also the air-space. Since it seems possible, under suitable conditions to observe a single electron, it follows that the apparatus may act as an extremely sensitive detector for X-rays. Thus a bundle of radiation representing 10^{-9} of the total radiation of an X-ray tube was detected ($0 \cdot 24 \times 10^{-11}$ cal./sec.). A second experiment consisted in submitting a particle of paraffin wax 1 cm.^{3} in volume to radiation from a Coolidge tube at a distance of 1 metre, the counter being placed at 8 cm. from the block and receiving only the radiation emitted laterally by the paraffin. It is shown that the number of electrons emitted, *i.e.* the number of collisions per micro-ampere through the tube per minute, is constant. Instead of direct observation it is not difficult by amplification to make the collision audible in a telephone, or using a relay to light a lamp, a very striking demonstration. It is pointed out that by a simultaneous use of two unconnected counters illuminated by the same X-ray wave a way might be found of testing the existence of a spatial quantum effect, *i.e.* of the "needle radiation." W. V. M.

860. *The Müller X-Ray Spectrograph.* (Engineering, 117. pp. 46–47, Jan. 11, 1924.)—An account of an X-ray spectrograph constructed to the design of A. Müller and available for use by several of the chief photographic methods. An elementary account of the conditions for strong reflection from crystals of X-rays leads to a brief account of the Bragg method available for large crystals, and Debye and Scherrer and again Hull's methods, applicable to crystalline powders and to rods and wires. The spectrograph is built up of interchangeable parts so that all methods may be used. Photographs and diagrams of the instrument are given, together with specimen photograms obtained using the various arrangements. W. V. M.

861. *The Standardising of Röntgen-Ray Doses.* **H. Behnken.** (Phys. Zeits. 24. p. 474 with Disc., Nov. 1–15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.) A. D.

862. *Dosimeter for Penetrating X-Rays.* **A. Dauvillier.** (Rev. Gén. d'Él. 14. pp. 887–902, Dec. 8, 1923.)—After discussing the various X-ray dosimeters in existence and their relative importance and accuracy in biological and medical work, the author describes an ionisation method which has particular value when the radiation is very penetrating. A. B. W.

863. *Theory of X-Ray Absorption and of the Continuous X-Ray Spectrum.* **H. A. Kramers.** (Phil. Mag. 46. pp. 836–871, Nov., 1923.)—The paper is divided into six sections dealing with: (1) Definition of the problems and statement of the main results; (2) the connection between the probability of absorption of radiation and the probability of emission of radiation due to the capture of a free electron; (3) the classical radiation from a free electron deflected by a positive nucleus; (4) the quantum theory of radiation from a free electron colliding with a positive nucleus; (5) the atomic absorption coefficient for homogeneous X-rays; and (6) the energy distribution in the continuous X-ray spectrum.

The paper is mathematical throughout, so that a short abstract is not possible. A. B. W.

864. *The Change of Wave-Length Accompanying the Diffusion of X-Rays.* **E. Bauer.** (Comptes Rendus, 177. pp. 1031–1033, Nov. 19, 1923.)—In a recent publication [see Abstract 2194 (1923)] Compton has disclosed the remarkable fact that when monochromatic X-rays are diffused by graphite, their wave-length increases according to the divergence from the incident ray. The present paper contains a critical discussion of Compton's explanatory theory based as it is on the hypothesis of light quanta, and the assumption that the electron may be considered as free, the forces binding it to the atom being sufficiently feeble to be neglected. The author now suggests another explanation based on the quantum hypothesis, but he indicates at the outset that the classical theory of light provides for an analogous effect in the case of diffusion by free electrons. The author cannot decide, however, which of the two theories corresponds best with reality. H. H. Ho.

865. *The Theory of the Diffusion of X-Rays.* **E. Bauer, P. Auger,** and **F. Perrin.** (Comptes Rendus, 177. pp. 1211–1212, Dec. 3, 1923.)—Compton's work on the diffusion of X-rays [see Abstract 2194 (1923)] has involved the use of a correspondence principle which is regarded as too arbitrary by the present authors. They propose a principle more in accordance with the essentials of the Bohr notion. This is an extension of Bauer's previous work [see preceding abstract] and the assumptions are made that the processes of diffusion of X-rays by a free electron may be subdivided as follows: (1) The electron commences by absorbing an entire quantum *hν* of the incident radiation, although whether by a continuous or discontinuous mechanism is not yet known. (2) The quantum absorbed is then radiated. The frequencies, intensities, and polarisations of the diffused radiation are, on the average, the same as if diffusion had been produced according to the classical laws by electrons excited by the speed *ν*. [Principle of correspondence.] Two hypotheses are possible for the re-emission of the quantum by the electron, *viz.* that it takes place as a train of spherical waves or of quantum projectiles. These viewpoints are discussed and the opinion expressed that experiments utilising C. T. R. Wilson's method should provide a decision. It is remarked that for the first time in the quantum hypothesis; the absorption and emission of light are related to modifications of a free electron, and not to those of an atomic complex. The electron is here the principal agent of the optical phenomenon, and from this standpoint the quantum theory approaches the classical theory. H. H. Ho.

866. *The Abnormal Reflection of X-Rays by Crystals.* **G. L. Clark** and **W. Duane.** (Science, 58. pp. 400–402, Nov. 16, 1923.)—In recent papers [see Abstract 2202 (1923)], the authors have described experiments which show that under certain conditions a crystal of potassium iodide deflects X-rays in a way that does not obey the ordinary laws of X-ray reflection. The discovery and extensive study of these abnormal reflections, called X-peaks, were made by means of ionisation spectrometers. These vanished when the voltage fell below the critical voltage required to produce the K-series lines of iodine, and the conclusion was drawn that the abnormally reflected rays consisted of the characteristic line spectrum excited by the primary X-radiation in the iodine atoms of the reflecting crystal itself. The angle of reflection so obtained from the crystal depended in a complicated way upon the angle of incidence of the primary rays, and the phenomenon cannot be regarded as ordinary reflection from any single set of crystal planes. The existence of the X-peak reflection was afterwards confirmed by the photographic method. Recent photographic work by Wyckoff, however, does not show this phenomenon, and the authors have in consequence repeated their experiments with the confirmation of their previous conclusions. The photographs show a large number of Laue spots reflected in the ordinary way from the various crystal planes together with the 4 well-defined spots that cannot be reflected from any conceivable planes in the crystal and which correspond exactly in position with the X-peak reflections. The important differences between the author's experiments and those carried out by Wyckoff are discussed at length. These include the use of a much higher voltage, a single pin-hole in a lead sheet to define the beam of X-rays incident on the crystal, and a thicker crystal of potassium iodide. This possibility of abnormal reflections is of great importance in the analysis of crystals. H. H. Ho.

867. *Radio-Luminescence and Radio-Photoluminescence.* **K. Przibram and Elizabeth Kara-Michailova.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 8. pp. 511–530, 1922.)—Radio-photoluminescence, *i.e.* the property after treatment with Becquerel rays of being excited by ordinary light to longer and stronger giving out of light, is shown by kunzite and fluorspar and also by apatite from Auburn, by orthoclase, adular, wollastonite, scheelite, and several tourmalines. The action is exhibited by the whole visible spectrum and also by the ultra-violet, X-rays and γ-rays. It has not hitherto been noticed in the infra-red. Treatment of kunzite by X-rays has the same effect as with Becquerel rays. The intensity of the luminescence light during exposure to β-γ-radiation first increases with time, and then slowly decreases after a very flat maximum. The total light (*i.e.* the total energy) determined by heating of kunzite exposed to radiation approaches with increasing duration of radiation a saturation value. The change of the light total with the duration of radiation is quite similar to the change of the optical absorption coefficient of kunzite with the duration of radiation, especially is the saturation value in the two cases approximately attained in the same time. The radio-photoluminescence of kunzite shows in its dependence on the wave-length of the exciting light similarity to the photoelectric effect: rise of the intensities converted from equal absorbed energy from the long towards the short waves and overlapping of selective maxima at about 565 and 475 $\mu\mu$. The ratio of these two wave-lengths 100 : 84 is the same as with two of the three excitation maxima of many specimens of Lenard's phosphorus (on the average 100 : 81·8). For the duration of illumination there is an optimum, after which the intensity again decreases. The action of the illumination is smaller, the longer the time which has elapsed between it and the end of the exposure to radium radiation. The energy liberated as light total with radio-luminescence at the maximum is only a small fraction of the absorbed γ-ray energy; similarly the energy sent out as light with radio-photoluminescence is small compared with the absorbed energy of the exciting light. There is evidence of the far-extending analogy between substances treated with Becquerel rays and the phosphorescent alkaline earths. J. J. S.

868. *Secondary Corpuscular Rays Produced by Homogeneous X-Rays.* **H. Robinson.** (Roy. Soc., Proc. 104. pp. 455–479, Nov. 1, 1923.)—The investigation now described is essentially a continuation of work previously carried out by the author and W. F. Rawlinson in 1914 [see Abstract 177 (1915)]. In the present experiments, however, more refined methods, aiming at an accuracy of 1 in 1000 in rH, have been employed. Tables of results are given, using the Kα_1 rays of copper, for the following elements: Bismuth, lead, gold, tungsten, barium, iodine, tin, silver, molybdenum, strontium, copper, calcium, potassium, sulphur, magnesium, sodium, and oxygen. The paper concludes with a discussion of the accuracy of the observations, on the relative intensities of the lines in the corpuscular spectra, and on the bearing of the results on the theory of atomic structure. **A. B. W.**

869. *Wave-Lengths of Secondary X-Rays.* **G. L. Clark** and **W. Duane.** (Nat. Acad. Sci., Proc. 9. pp. 413–418, and 419–424, Dec., 1923.)—Secondary radiation contains a large number of scattered rays of precisely the same wave-lengths as those of the primary rays. Except with copper no scattered rays were found whose wave-length was a certain fraction of an Ångström longer than those of the primary rays [Compton, Abstract 901 (1919)]. There must also be tertiary rays having wave-lengths longer than the primary rays by a certain amount extremely small except in copper; which would explain the results obtained with copper. [See Abstract 384 (1920).] **A. D.**

870. *A New Secondary Radiation of X-Rays.* **W. Bothe.** (Zeits. f. Physik, 20. 3–4. pp. 237–255, 1923. From the Reichsanstalt.)—In a previous paper [Abstract 98 (1924)] photographs taken by the Wilson cloud method were held to show the presence of an intra-atomic H-radiation, which did not satisfy the photoelectric $h\nu$ relation. The author has shown his previous conception to be untrue, as the new rays are electronic rays, which find their explanation in the recent quantum theory of the scattering of X-rays, due to Debye [Abstract 1878 (1923)]. The present paper is a lengthy one in which experimental apparatus is discussed in much detail and measurements are carried out concerning the phenomena in air, hydrogen, and helium. The nature of the radiation is then discussed, together with the effects of filtration, of application of a magnetic field, and the effects of aluminium, graphite, and paraffin. The theoretical aspects are then dealt with, based upon Debye's theory and also the effect of variation of voltage applied to the X-ray tube. The results, owing to monochromatic radiation not being used, do not closely satisfy Debye's quantum theory of scattering, but are nevertheless held both to prove this theory and the general quantum theory. **B. J. L.**

871. *Excitation of Characteristic X-Rays from Certain Metals.* **F. Horton, Ursula Andrewes,** and **Ann C. Davies.** (Phil. Mag. 46. pp. 721–741, Nov., 1923.)—Investigations of the voltages connected with some of the longer wave-length absorption limits have been made for the elements Al, Fe, Ni, Cu, and Zn by the excitation potential method. The following critical values have been obtained:

For aluminium	42, 66, and 107 volts
For iron	73 and 166 volts
For nickel	104 ,, 178 ,,
For copper	112 ,, 193 ,,
For zinc	119 ,, 200 ,,

By extrapolating the Moseley curves for the various absorption limits to low atomic numbers, the lower of the two values obtained for each of the metals, iron ($z = 26$), nickel ($z = 28$), copper ($z = 29$), and zinc ($z = 30$), was found to be associated with the $M_{II\text{-}III}$ level, and the higher of the two values obtained for each of these elements was found to be associated with the M_I level. The changes on the slope of the M_I and $M_{II\text{-}III}$ curves in passing through the observed points support the view that a change in the constitution of the M electronic group is in progress as we pass from one of these elements to another. The results suggest that the development of the second M sub-group from 4 electrons to 6 electrons, as required by Bohr's theory, does not commence before the element cobalt ($z = 27$), but that the similar development of the first M sub-group commences for a lower value of the atomic number.

By extrapolating the Moseley curves for the L absorption limits in a similar way, the two higher values found for aluminium have been connected with the L_{I}. and $L_{II\text{-}III}$ levels respectively. From analogy with the anomalous K absorption limits found by Fricke for titanium, vanadium, and chromium, which Coster suggests are due to the displacement of an electron from the K group to an incomplete M sub-group, it seems probable that the lower value (42 volts) found for aluminium is to be associated with the displacement of an electron from the second L Sub-group to the first M sub-group. A. B. W.

872. *Observations with X-Rays upon Fluorescent Zinc Silicate.* **A. Schleede** and **A. Gruhl.** (Zeits. Elektrochem. 29. pp. 411–412, Sept., 1923. Paper read before the Deut. Bunsen Gesell, Hanover, 1923.)—Reference is made to previous work by Schleede and Tiede on calcium tungstate [Abstract 2426 (1923)]. New experiments are described upon zinc silicate containing a trace of manganese and cooled at different rates, to give varieties which show green, yellow, and red fluorescence. These can be shown to be modifications of the same body by heating to about 900° C., when the red and yellow forms pass to the green form. X-ray examination of the crystal structure of the three forms was carried out by the Debye and Scherrer method and show differences in the spectra. It is concluded that the various emission bands of a substance depend upon the spatial crystal form. B. J. L.

873. *The Production of X-Ray Fluorescence and the Question of the Comparison of the Intensity of X-Rays of Different Wave-Lengths.* **W. Kossel.** (Zeits. f. Physik, 19. 5–6. pp. 333–346, 1923.)—The fluorescence referred to is the production of secondary X-rays (γ-rays), when a beam from a Röntgen tube falls on a body. On the theory that the primary ray or wave generally removes an electron more or less completely from the atom, leaving it in an "excited" state, and that it is only after a certain interval that one of the loosely bound electrons fills up the resulting gap, the energy lost by it being converted into a secondary X-ray, it follows from the quantum theory that a given level will give off X-rays of a definite frequency; this frequency will in no way depend on that of the primary X-ray concerned, which merely must contain sufficient energy in its quantum to eject the original electron from the level concerned. It follows that if each of the absorbed primary quanta acts in this way the number of secondary quanta emitted will be the same as that of the primary quanta, and a method becomes available for measuring the relative intensities, or amounts of energy, contained in X-ray beams of different wave-length, making use of the relation $E = h\nu$. Methods are suggested for carrying out such measurements, the various difficulties being pointed out. It is shown that Sadler's results, based on ionisation measurements, lead to the conclusion that μ, the ratio of the number of secondary quanta emitted to the primary quanta absorbed, is constant for a given element; the value varies from element to element increasing with the atomic weight, being 0·25 for Cr and 0·51 for Zn. The author concludes that it is possible that these values are really too small, and that in the case of the K layer μ may reach unity, so that every excitation of the K mechanism leads to the emission of a quantum of energy of one of the K-lines. H. N. A.

874. *Corpuscular Radiation Excited by X-Rays.* **C. G. Barkla** and **(Miss) A. E. M. M. Dallas.** (Phil. Mag. 47. pp. 1–23, Jan., 1924.)—The energy of the corpuscular radiation emitted by metal plates when exposed to X-radiation of varying frequency has been investigated by a simple method. The results differ substantially from those obtained by other investigators using different methods. They show two independent discontinuities in corpuscular emission due to the α- and β-constituents of the K-radiation when this is used to excite corpuscular emission. They show that few K-electrons have energy of the order hn where n is the frequency of the exciting radiation. From silver and tin these electrons are altogether insufficient in number to account either for the observed increase in ionisation or for the full energy of characteristic radiation on the basis of one quantum of characteristic radiation for one high-speed electron. In this respect these results differ markedly from those obtained by other investigators of the emission from metal plates. The inadequacy of these electrons thus points to the importance of the part being played by other electrons with energy $h\,(n - n_k)$, such as found by de Broglie; these would not be detected by the plate experiments. On the other hand, the ionisation experiments of Barkla and the results of experiments by Sadler, Beatty, and Bragg, on the emission of electrons from metal plates, all indicate that the bulk of the energy in the corpuscular radiation—the K-corpuscular radiation—is in the electrons of energy approximately hn. Such experiments have been made, however, in substances of lower atomic weights. These substances are now being studied by more exact methods. A. B. W.

RADIO-ACTIVITY.

875. *The Photographic Action of Becquerel Rays.* **R. Wälder.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 8. pp. 495–510, 1922.)—If a plate is first exposed to α-, β-, or γ-rays, so as to produce a latent image, and then exposed to light from an incandescent lamp, a reversal takes place; the places on the plate on which both kinds of ray have fallen are found, after development, to be brighter than those to which no light has penetrated, and in some cases brighter than those which have received light only. The effect is not observed when the exposures are made in the opposite order. The curves obtained when one kind of radiation is kept constant, and the other is varied, are **U** formed, which seems to indicate that two different actions are taking place, in part at least simultaneously, one of which blackens the plate, while the other bleaches it; and the author, after an experimental investigation, suggests that, when absorption of radiation takes place, the silver bromide molecules receive different quantities of energy; some of them are split up, metallic silver being separated, while others are merely activated, receiving a smaller amount of energy than the first. The greater the energy density of a radiation the greater is the proportion of the molecules which are split up, and the smaller that of those which are merely activated; so that the Becquerel rays, which have a greater energy density than light rays from an incandescent lamp, will produce a larger number of silver atoms, and a smaller number of activated molecules than the latter. At the same time it must be assumed that, under the action of either kind of radiation, the liberated silver atoms enter into chemical combinations, which are not capable of development; the result being that, when ordinary light acts upon the latent image caused by the Becquerel rays, its action is mainly on these silver atoms, and so is a bleaching one; the number of activated molecules is small; the darkening produced by the action of the light on these, and on any unattacked AgBr molecules, may be considerably less than this bleaching action, and the result is that the image is reversed. H. N. A.

876. *Colouration and Luminescence Produced by Becquerel Rays.* **S. Meyer** and **K. Przibram.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 6–7. pp. 429–435, 1922.)—The authors have investigated a number of crystals and different kinds of glass, observing the effect of heating and exposure to light. Thermo-luminescence has been observed at remarkably low temperatures in these substances when coloured by the Becquerel rays; and bleaching action begins at surprisingly low temperatures even in cases in which the substance resists the action of daylight. When glasses are coloured violet by the rays it appears that, in many cases, this is due to the presence of manganese. Kunzite from Pala in California is coloured green by the rays; but in the case of the same substance from Madagascar a brown colour is observed; after heating to 87° this colour changes to green, and it appears that there are two superimposed effects in the case of the Madagascar specimens, one of which gives the brown colour, and is destroyed by heat, while the other, which causes the green colour, is common to specimens from both sources. With the brown colour is associated a more intense phosphorescence which, with the brown colour, dies out more rapidly under the influence of heat than the green colour, and the phosphorescence linked with it. Examining the splendidly luminescent Tiede phosphores, it was found that strong Becquerel radiation destroys the luminescence; when terephtalic acid phosphore was heated, after this treatment, the phosphorescence was regenerated, and may even be strengthened, but is shifted towards longer wave-lengths. H. N. A.

877. *Investigations upon the Penetration of Radio-Active Substances into Metals.* **(Miss) S. Maracineanu.** (Comptes Rendus, 177. pp. 1215–1217, Dec. 3, 1923.)—The penetration hypothesis with respect to the supporting metals has been evolved by Curie to explain the divergence between the values found for the constant of polonium. The present paper contains a description of some experiments made with polonium and actinium to test this hypothesis. The first investigations were made at the ordinary temperatures by allowing drops of a polonium preparation to evaporate upon very thin layers of gold and lead which are then examined for radioactive content. Proof of this has been established but no success was obtained when glass was used instead of a metal. Increased penetration is found when the experiments are conducted at temperatures of 180° to 200°, but again no penetration into glass was detected. Support is thus afforded for the Curie hypothesis. H. H. Ho.

878. *Measurement of Amount of Radium in Naturally Occurring Titano-Niobates.* **A. Karl** and **S. Lombard.** (Comptes Rendus, 177. pp. 1036–

1037, Nov. 19, 1923.)—Most of these minerals are fusible in potassium bisulphate, and the melt remains perfectly clear, even when a good deal of sulphuric anhydride is driven off in the form of white vapour. The liquid mass retains no trace of emanation after a current of air is passed through it. The fusion point can be lowered considerably by adding sulphate of soda in the proportion needed to obtain a eutectic mixture, and can be lowered further by the addition of lithium sulphate. The solidified mixture is broken up, and pieces are introduced into a test tube of Pyrex glass, with a rubber stopper through which pass two tubes of the same glass. The mixture is then melted in a Bunsen flame, and is perfectly fluid at 550° to 600° C.; air is then drawn through, to remove the emanation, which is measured in the usual way, precautions being taken to remove any acid vapours in the air. H. N. A.

879. *The Applicability of Normal Radium, and Uranium Solutions for Emanation Measurements. Part II.* **P. Ludewig** and **E. Lorenser.** (Zeits. f. Physik, 21. 4. pp. 258–263, 1924.)—The former investigation [see Abstract 1594 (1923)] has been continued for a second year, when the solutions then employed have been found not to lose their utility even after being used 9 times. During the two years they have remained constant within 2 %. The dependence upon pressure of the ionisation effect of the γ-radiation of a radium preparation and of the α-radiation of an emanation has now been experimentally investigated. This observed dependence has been used for the calculation of the amount of an emanation. Tables of data are included. H. H. Ho.

880. *Determination of the Rate of Decay of the Short-Life Product Radium C′.* **J. C. Jacobsen.** (Phil. Mag. 47. pp. 23–31, Jan., 1924.)—Geiger and Nuttall's relation between the transformation constant λ for radio-active substances emitting α-rays, and the range R of the rays, $\log \lambda = a + b \log R$, has since been shown to be not very exact; but if λ is calculated from the formula for RaC′, using the observed value $R = 6{\cdot}608$ cm. the value $\lambda = 5 \times 10^7$ sec.$^{-1}$, or the half-period value $T = 0{\cdot}35 \times 10^{-7}$ sec. is obtained. In order to measure λ experimentally a quantity of the same order of magnitude is required with which to compare it, and the velocity V of the recoil atoms from RaC has been made use of for this purpose. There is difficulty in calculating this velocity, on account of the uncertainty as to the velocity of the primary β-rays from RaC; but assuming this to be $v = 0{\cdot}996\,c$, $V = 8{\cdot}4 \times 10^5$cm./sec. A plate or disc of polished nickel was coated with RaC by a special process, and placed at one end of a tube, along the thick side of which were a number of equidistant slits perpendicular to the axis of the tube; a stream of RaC′ recoil atoms was sent out along the tube, from which the air was exhausted, and after moving a certain distance each recoil atom is transformed into RaD, with the emission of an α-particle. Some of these α-particles will be ejected at right angles to the movement of the recoil atoms, that is to say, some of them will pass through the different slits in the tube, and can be observed and counted on a zinc sulphide screen; the experiments made so far cannot be regarded as definitive, but they give the value of λ/V as about unity, or $\lambda =$ about $8{\cdot}4 \times 10^5$, or $\log_{10} \lambda = 5{\cdot}9$, while the value predicted by the Geiger-Nuttall formula is $7{\cdot}5$. If V is calculated from $\lambda/V = 1{\cdot}0$ and $\log_{10} \lambda = 7{\cdot}7$ the value 5×10^7 is obtained, or 60 times the value used above, this would imply the existence of enormous velocity in the primary β-rays from RaC, and the existence of such very hard rays seems very improbable. It appears then that the value of λ predicted by the Geiger-Nuttall formula is definitely too high. Control experiments were carried out to determine the velocity of the RaC′ recoil atoms, by measuring the range in air; they are not very complete as yet, but a curve is given in the original paper which shows the number of scintillations in 100 sec. corrected for decay of the source plotted against the pressure in the apparatus. H. N. A.

881. *The Radio-Activity of the Alkali Metals.* **G. Hoffmann.** (Phys. Zeits. 24. pp. 475–476; Disc., 476, Nov. 1–15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—A highly sensitive, photographically registering, vacuum electrometer was employed, in connection with an ionisation chamber, which was as far as possible non-radioactive, and which was protected from penetrating radiation by a lead covering 3 cm. thick. The salts investigated were powdered in a thin layer on a lacquered metal support. In one set of experiments the surface was 250 sq. cm., and the distance from the ionisation chamber was 3 cm., when only the β- and γ-radiation could penetrate; in a second set the surface was 10 sq. cm., and it was brought right up to the chamber, so that weak β- and γ-radiation and α-rays could penetrate. Fractions of a milligramme of rubidium could be detected. The first method gave as upper limit for the action of a possible Na radiation 1/500 of the potassium radiation, while the second, which included the soft radiation gave 1/50. Cæsium chloride (Kohlbaum) showed radiation similar to that of rubidium; but the cæsium mineral *pollux* (polluscite) showed no radiation; the radiation of the cæsium chloride was apparently due to about three per cent. of rubidium impurity. The fresh powdered salts showed generally less α-activity than freshly scaped copper, or less than $0{\cdot}2$ α-particles per sq. cm. per hour, *i.e.* less than would be given by 2×10^{-12} grammes of radium per gramme of salt; the specific α-activity is certainly very small. The results agree well with those of Hahn; taking the radioactivity of K as 1, method 1 gives $\mathrm{Na} < 0{\cdot}001$, $\mathrm{Rb} = 4{\cdot}4$; method 2 gives $\mathrm{Na} < 0{\cdot}02$, $\mathrm{Rb} = 7{\cdot}6$. H. N. A.

882. *Colouration and Luminescence Produced by Becquerel Rays.* **K. Przibram.** (Zeits. f. Physik, 20. 3–4. pp. 196–208, 1923.)—The paper gives a *résumé* of work done during recent years in the Vienna *Institut für Radiumforschung*; it has been found that the particles which give the colouration are so small that, when first produced, they cannot be resolved by the ultramicroscope, as can be done with materials coloured with Na vapour. With many salts of the alkalis, particularly the borates, the colour agrees with that of the vapour of the particular alkali, or of its organic sols; in other cases, as in NaCl which is coloured amber, the anion may be concerned. From the large amount of experimental detail considered the author concludes that the primary process is the absorption of a radiation quantum (wave or corpuscular) by a negative ion, such as Cl in NaCl, the extra electron being split off; this electron can pass to the positive metallic ion, and neutralise it; the result is an emission of light (radio-luminescence) and the substance is coloured with the colour of the metal; when the Becquerel radiation ceases the process may be reversed, owing to thermal movements; the most loosely held electron of the metal may either go to the electro-negative component, producing discoloration, or in certain cases it may fall back into its orbit, with the emission of light. In some cases this takes place at ordinary room temperature; treated fluorspar, for example, phosphoresces in the dark; in other cases heat is necessary to produce this effect, the colour being destroyed. Light may produce the same effect as heat; this may be due to its heating effect on the centres of phosphorescence, or to a photoelectric effect on the metallic ion. The fact that the colouration reaches a saturation value is ascribed to the superposition of two actions, a colouring process due to the radiation, and a bleaching action which proceeds continuously, sometimes even in the dark, or under the action of the rays, being in some cases increased, or even caused, by their action; as in the case of rock salt, which retains its colour in the dark. The centres are found to agglomerate when the crystals are heated, so that they become visible in the ultramicroscope; this indicates the possibility of considerable movements of translation in the crystal lattice. H. N. A.

883. *Is Cæsium Radio-Active?* **H. Zwaardemaker, W. E. Ringer, and E. Smits.** (K. Akad. Amsterdam, Proc. 26. 7–8. pp. 575–581, 1923.)—The alkali metals K and Rb are radio-active, and it has been suspected that Cs also has slight radio-activity. The authors have tested the point by a physiological method, passing a solution of cæsium chloride through a frog's heart, as has already been done by S. Ringer, and noting that the continuation of the heart's beating, the minimum, the optimum, and the highest practicable dosis, depended on the source and degree of purity of the CsCl employed. The conclusion is that the impurity that imparts to commercial preparations of cæsium a feeble radiating power, is presumably a heavy radio-active element; and that the biological action of this impurity has the nature of a β-radiator. H. N. A.

884. *Relative Ionisation along the Path of α-Rays in Different Gases.* **F. Hauer.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 9. pp. 583–587, 1922.)—The ionisation along the path of a parallel bundle of α-rays in air, oxygen, helium, and CO_2 is measured and it is found that the number of generated ions per unit of length of the path increases, with the distance of the source of the rays (polonium), so much the quicker the lighter the gas through which the rays pass. From this the conclusion is drawn that the loss of energy which an α-particle suffers by the generation of a pair of ions in a certain gas is given not alone through the work necessary for ionisation, but that in addition there is a certain amount of energy loss which depends on the velocity of α-particles and the density of the gases through which the rays pass. A. E. G.

885. *On the Correction for Non-Uniformity of Field in Experiments on the Magnetic Deflection of β-Rays.* **D. R. Hartree.** (Cambridge Phil. Soc., Proc. 21. pp. 746–752, Nov. 14, 1923.)—The rays from a point source pass through a slit and, after having been bent by an approximately constant magnetic field, fall upon a photographic plate. Were the field exactly constant the trajectory would be circular, and the object of the paper is to study mathematically the effect of small variations in the field. The argument employed is a special case of a well-known method of calculating the first order variations of the solutions of any system of differential equations; and the results obtained are applied to two particular experimental arrangements. H. N. A.

886. *The Number of Pairs of Ions Produced by an α-Particle from RaC.* **H. Fonovits-Smereker.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 4–5. pp. 355–363, 1922.)—Previous determinations of the number n of pairs of ions per α-ray have not led to a definite trustworthy result. H. Geiger recently found, by an indirect method, for RaC $n = 2{\cdot}37 \times 10^5$ and the authoress, using a direct method, has measured it for the same substance in air, by determining the value of the saturation current i for a gold foil activated on one side with RaC, and the radium equivalent r of the same foil by comparison with a standard radium preparation. The mean of 15 determinations gave $n = 2{\cdot}20 \pm 0{\cdot}02 \times 10^5$; n has been calculated for all other substances emitting α-rays from their ranges.

H. N. A.

887. *A Possible Explanation of the Continuous β-Ray Spectrum.* **L. Meitner.** (Zeits. f. Physik, 19. 5–6. pp. 307–312, 1923.)—The author renews the investigation as to the manner in which a radio-active element which ejects a β-particle or electron disintegrates [Abstract 2451 (1923)]. A. H. Compton has shown, in a series of investigations, that when X- or γ-rays strike matter the scattered radiation has a greater wave-length than the incident; this increase is a function of the angle of scattering, and is greatest when this is 180°; Compton, and also Debye, have deduced from this that the classical theory for the scattering of radiation by a free electron breaks down, and that a quantum process must be assumed. If a quantum $h\nu_0$ is scattered by a free electron of mass m, the energy is divided between $h\nu$ for the scattered radiation, and the kinetic energy E_β imparted to the electron. Thus, when γ-rays are scattered by free or almost free electrons, a continuous β-ray spectrum will be produced, with a definite limit on the fast ray side. The γ-rays from the nucleus must be scattered by the outside electrons of the atom; and, in addition to the "photo-effect" which produces the β-ray lines, there will be a scattering effect which gives a continuous spectrum, with a definite limiting velocity. The equations obtained show that the ordinary photo-effect, in which the inner forces of the atom are important and in which the whole of the γ-ray energy goes to the electron, to separate it from the atom, and give it a certain velocity is more and more replaced by the scattering effect, when the incident γ-ray wave-length is diminished, *i.e.* when the energy of combination of the electron is small compared with the incident quantum of radiation; this is connected with the fact that no Compton scattering effect has been observed in the optical region. The K-electrons absorb the γ-radiation more than the outer electrons. If the γ-wave-length is very short even the K-electrons can be regarded as loosely bound and the scattering will be large, the β-lines weak, with a strong continuous background, which, if there is only one γ-wave-length, will have a sharp limit on the high-velocity side; such a limit is always seen in the photographs. Every substance which radiates γ-rays must, then, give a continuous γ-ray spectrum, in addition to its monochromatic γ-lines; and this will produce a tertiary, continuous β-line spectrum. These considerations also give some explanation of the intensity relations of the observed lines.

H. N. A.

HEAT.

888. *Thermometer Calibration.* **E. Schottländer.** (Zeits. Instrumentenk. 43. pp. 265–274, Sept., 1923.)—The influence of scale divisions on the distribution of errors is considered chiefly in relation to thermometers. Richter's Kipp thermometer is especially considered. W. A. R.

889. *Colour Temperature Measurement.* **O. Reeb.** (Zeits. techn. Physik, 4. 10. pp. 389–391, 1923.)—Describes the use of a combination of tungsten filament vacuum lamp and blue glass for the determination of the colour temperature of sources of light. J. W. T. W.

890. *Free and Forced Convection of Heat in Gases and Liquids.* **C. W. Rice.** (Am. I.E.E., J. 42. pp. 1288–1289; Disc., 1289–1293, Dec., 1923. An abridgement of a paper presented at the Annual Convention of the A.I.E.E., June 27, 1923.)—It is pointed out that a mathematical solution of a convention problem would require a knowledge of the hydro-dynamic laws of viscous fluids for stream line and turbulent motion. Lack of the hydrodynamic laws for turbulent motion render a vigorous solution impossible. Langmuir adopted a film theory as an approximation. Consider a horizontal heated wire. At the surface of the wire the fluid is stationary, due to viscosity. As we proceed from the surface of the wire, the velocity of the convection currents increase until a distance is reached at which the critical velocity conditions in the fluid are exceeded and the stream line flow bursts into turbulent motion. The discontinuity between the stream line and turbulent motion constitutes the outer boundary of the film. The question of how the film thickness varies with the size and shape of the body and properties of the ambient fluid is determined by Raleigh's "Method of Dimensions." E. G.

891. *A Thermostat Refrigerator.* **K. C. D. Hickman.** (Chem. Soc., J. 123. pp. 3416–3417, Dec., 1923.)—A contrivance for keeping a bath at 15° C. through summer and winter. In the summer there is a play of ice-water, in winter a play of gas-heated water. A. D.

892. *Comparison of the Heating-Curve and Quenching Methods of Melting-Point Determinations.* **G. W. Morey.** (Washington Acad. Sci., J. 13. pp. 326–329, Aug. 19, 1923.)—The heating-curve method, which is the method followed almost exclusively in the study of metals and salts which crystallise readily, is compared with the quenching method, used chiefly in the study of substances which are difficult to crystallise such as most silicates. It is well recognised both in theory and practice that the melting-point of a substance of the latter class is more accurately determined by the quenching method. In this method a few milligrams of the substance are wrapped in thin platinum foil and held at a definite temperature until equilibrium is reached. The substance is then suddenly cooled and examined under the microscope. If the heating has been above the melting-point the examination shows only glass, but if below the melting-point only crystals. The method is thus only applicable to substances which are sluggish crystallisers. Taking the melting-point determination by this method as standard, it is shown that the true melting-point lies on the more rapidly rising end portion of the heating curve. As usually interpreted, therefore, the heating-curve method tends to give a melting-point which is too low. The difference in the present case (sodium metasilicate) is of the order of magnitude of 2° C. or less at about 1100° C. T. H.

893. *A Calorimetric Method of Surveying the Behaviour of Steam.* **N. S. Osborne.** (Mechanical Engineering, 46. pp. 88–90 and 108, Feb., 1924.)—Describes the elements of a method of calorimetry of a saturated fluid which is adapted to the determination of some thermal properties of steam at the saturation limit. This method is the basis of the experimental programme of research on the properties of steam upon which the Bureau of Standards is at present engaged. S. L. S.

894. *Progress Report on Work at Harvard University on the Joule–Thomson Effect.* **R. V. Kleinschmidt.** (Mechanical Engineering, 46. pp. 84–85, Feb., 1924.)—Describes improvements made in the apparatus employed at Harvard in research on the Joule–Thomson effect in superheated steam. S. L. S.

895. *Progress Report on the Joule–Thomson Effect.* **H. M. Davis.** (Mechanical Engineering, 46. pp. 85–87 and 108, Feb., 1924.)—Reviews the present position of the steam research on the Joule–Thomson effect carried out at Harvard. S. L. S.

896. *The Three-Temperatures Rule.* **C. Porlezza.** (N. Cimento, 25. pp. 291–303, May–June, 1923).—If τ_f be the absolute temperature of fusion, τ_b that of boiling at ordinary pressures, and τ_c the critical temperature (abs.), the expression $\tau_f + \tau_b = k\tau_c$ appears justified. Prud'homme and the author find k approx. = 1, Lorentz found 1·11. A. D.

897. *The Four-Volumes Rule.* **C. Porlezza.** (N. Cimento, 25. pp. 305–306, May–June, 1923.)—To a first approximation, the critical specific volume is equal to the sum of the specific volumes at absolute zero, at fusing-point and at boiling-point. A. D.

898. *Partial Pressures of Sulphuric Acid over Concentrated Aqueous Solutions of the Acid at High Temperatures.* **J. S. Thomas** and **A. G. Ramsay.** (Chem. Soc., J. 123. pp. 3256–3270, Nov., 1923.)—The assumption that, even in concentrated solution, sulphuric acid exerts no vapour pressure, the vapour consisting solely of water, is not warranted, since filter-paper becomes charred when kept for several months over the concentrated acid in a desiccator. It is now shown, indeed, that the partial pressure of the acid is measurable at temperatures above 200° when the concentration of the solution exceeds 85 per cent. By means of a dynamical method the partial pressures of the acid vapour over sulphuric acid-water mixtures containing from 86 to 99·6 per cent. of the acid have been measured at temperatures ranging from 160° to 260°. The results obtained show that the partial pressures may be represented with considerable accuracy, except at the highest temperatures, by the expression,

$\log p = \alpha + \beta T + \gamma T^2 + \text{etc.}$, or $\log p = \alpha - \frac{\beta}{T} - \frac{\gamma}{T^2} - \text{etc.}$ The equation given by Lehfeldt (Phil. Mag. 40. p. 402, 1895) to express the relationship between the total vapour of a mixture and the vapour pressures of the constituents is not valid for concentrated solutions of sulphuric acid in water. Dissociation of the acid occurs at temperatures above 220°, the degree of dissociation calculated for 250° being 0·09.

The value of the latent heat of vaporisation of sulphuric acid is calculated from the experimental results obtained, and an attempt is made, but with only partial success, to account for the abnormally high values obtained at temperatures above 230° by the introduction of the heat effects due to the dissociation of the acid. T. H. P.

899. *Temperature of Vapour from a Solution.* **O. Knoblauch** and **H. Reiher.** (Zeits. techn. Physik, 4. 11. pp. 432–433, 1923.)—From experiments which are described the authors conclude that, contrary to the recent deductions of K. Schreber, the temperature of the vapour from a solution is the same as that of the solution. G. A. S.

900. *Temperature of Vapour from a Solution.* **F. Pollitzer.** (Zeits. techn. Physik, 4. 11. pp. 433–434, 1923.)—A theoretical argument to show that the contention that the temperature of the vapour from a solution is below that of the solution is in contradiction to the second law of thermodynamics. G. A. S.

901. *Temperature of Vapour from a Solution.* **K. Schreber.** (Zeits. techn. Physik, 4. 11. pp. 434–436, 1923.)—Contends that F. Pollitzer's argument overlooks the fact that the surface of a solution is a semi-permeable membrane and that an osmotic pressure exists at it which demands a discontinuity in temperature. But for this pressure it would, as Pollitzer argues, be possible to obtain mechanical work by drawing heat from the solution. The results obtained by O. Knoblauch and H. Reiher are probably due to heating of the thermometer bulb by radiation from the surrounding tube which is in contact with still air heated by an oil jacket. The only objection raised against the author's experimental arrangements, *viz.* the possibility of emergent stem error in his thermometer, is eliminated by a rearrangement of the apparatus in which the stem is kept at a higher temperature than the solution. The registered temperature is still 100° C. G. A. S.

902. *A Determination of the Vapour Pressures of Cæsium and Rubidium, and a Calculation of their Chemical Constants.* **D. H. Scott.** (Phil. Mag. 47. pp. 32–50, Jan., 1924.)—A modification of Haber's vibrating quartz fibre manometer [Abstract 234 (1915)] has been employed in the determination of the vapour pressures of cæsium and rubidium between 50° and 130° C. With this instrument an observation is made of the time T taken for the amplitude of vibration in the gas or vapour concerned to diminish from 50 scale divisions (about 0·63 mm.) to 40. This time T is connected with the vapour pressure p by the relation $b = T(\Sigma p M^{1/2} + a)$ where a and b are constants determined by calibration against a McLeod gauge, and M signifies molecular weight. A check determination of the vapour pressure of mercury was first carried out, giving a mean value of 0·00130 mm. at 20° C. In the case of cæsium and rubidium it was found that a linear relation existed between log p and $1/\mathrm{T}$ over the range 50°–130° C. The results can be represented by $\log p = 7\cdot256 - 3753/\mathrm{T}$ for cæsium, and $\log p = 7\cdot331 - 4209/\mathrm{T}$ for rubidium. From the figures obtained the chemical constants of the two metals were calculated and found to be in agreement with the formula $\mathrm{C} = 1\cdot5 \log \mathrm{M} + \mathrm{C}_0$, where C is the chemical constant, M the molecular weight and C_0 the "absolute chemical constant." The values obtained for C were $1\cdot64(0) \pm 0\cdot16(4)$ for cæsium and $1\cdot36(6) \pm 0\cdot18(4)$ for rubidium. The value of Trouton's coefficient $\lambda_{\mathrm{TB}}/\mathrm{T}_{\mathrm{B}}$ where λ is the molecular latent heat and T_{B} is the boiling-point is also calculated, giving 18·2 for cæsium and 19·9 for rubidium. T. B.

903. *The Vapour Pressure of Cadmium and its Alloys with Zinc.* **A. C. Egerton** and **F. V. Raleigh.** (Chem. Soc., J. 123. pp. 3024–3032, Nov., 1923.)—The vapour pressures of molten cadmium and zinc alloys have been measured at two temperatures. Raoult's law is found to rule. Measurements of the vapour pressure of cadmium are critically studied, and the value for the chemical constant of cadmium has been confirmed and agrees closely with the theoretical value. E. G.

904. *Vapour Pressure of Nitric Oxide.* **H. Goldschmidt.** (Zeits. f. Physik, 20. 3–4. pp. 159–165, 1923.)—Measurements on the vapour pressure of nitric oxide have been made by Atwentowski (Anz. d. Akad d. Wissensch., 1909. S. 142). Some of these showed such large irregularities that the present author has repeated the experiments. The results are given in tables and compared with calculations from Nernst's vapour-pressure formulæ. Atwentowski used two Stock thermometers [Abstract 662 (1907)] filled with NO and placed in a thermostat. The author used Stock thermometers of the Siemens type [Abstract 269 (1914)] which have the advantage that they can be closed by fusing. The thermometers were placed in a metal thermostat of the Henning type [Abstract 1800 (1921)], the temperature of which was read by a platinum resistance thermometer and by a methane-filled Stock thermometer, these temperatures being read immediately before and after the reading of the vapour pressure. Vapour pressures were measured from − 151° C. to − 174° C. From the vapour-pressure formula, the boiling-point of NO is − 151·13° C. and the critical point − 163·21° C., the vapour pressure at the latter point being 170·2 mm. Atwentowski concluded from his measurements that the vapour of NO was strongly associated. The present author shows that this cannot be the case, but that the liquid NO is strongly associated. This is confirmed by the value of Trouton's constant, which is found to have the value of 26·1 instead of the normal value 22. Finally the latent heats of evaporation and fusion are calculated with the help of the Clausius-Clapeyron equation. T. B.

905. *The Molecular Association of Liquids and Highly Compressed Gases. Parts I and II.* **E. E. Walker.** (Phil. Mag. 47. pp. 111–126, Jan., 1924.)—*Part I. Molecular Association at the Critical Point.*—Van der Waals' equation is known to be inaccurate at the critical point, and for this and other reasons the following modified equation has been used by Dieterici and others: $(\mathrm{P} + a/\mathrm{V}^{5/3})\,(\mathrm{V} - b) = \mathrm{RT}$ . . . (1). It is much more accurate than van der Waals' equation at the critical point, but fails for gases at moderate pressures. Here V represents the volume of a gramme-molecule. If the substance is associated, n_c V may be substituted for V, n_c being the association factor at the critical point. Solving for n_c, we get $n_c = 4RT_c/15P_cV_c$ . . . (2). The critical coefficient RT_c/P_cV_c is, however, not quite constant even for the paraffins where n_c is considered to be unity. The author shows that this critical coefficient is a function of the length of the molecule in the case of the saturated paraffins and also some other normal substances. If this function be introduced, then $(P + a/(n_cV)^{5/3})\ (n_cV - b) = RT \times 1/f(l)$ . . . (3), and we get $n_c = (4RT_c/15P_cV_c) \times 1/f(l)$, where $f(l) = 0{\cdot}838 + 0{\cdot}174 \log l$, the latter value having been chosen so that n_c is approximately unity for the saturated paraffins. Making use of these relationships, the association factors of a large number of substances at the critical point have been calculated. The values obtained are reasonable from the point of view of the general properties of these substances.

Part II. The Influence of Molecular Association on the Critical Constants.—Equation (3) above has been shown to be very nearly accurate at the critical point. If the molecular attractive power "*a*" and the molecular volume "*b*" were strictly additive quantities their values for double molecules would be $2a$ and $2b$. This is not the case, however, especially in the case of *b* in very small molecules such as hydrogen and methane. These divergences are shown by the present author to be representable as a function of the molecular length. For *a* and *b* in equation (3) the following expressions are substituted: $a = \alpha \times [f(l)]^{2/3}$, $b = \beta \times f(l) \times f'(l)$, where $f(l) = 0{\cdot}838 + 0{\cdot}174 \log l_1$ and $f'(l) = 12{\cdot}2/l^3$. As α and β are now very nearly additive it is possible to write 2α and 2β for double molecules. The results of calculations on this basis are found to be in good agreement with existing experimental data. T. B.

906. *The Existence in Nature of Processes which may be Considered as Cases of Perpetual Motion of the Second Class, and Some of the Consequences.* **R. v. Dallwitz-Wegner.** (Zeits. techn. Physik, 4. 11. pp. 408–418, 1923.)—In this paper the author attempts to show that there are many cases of the conversion of heat into work to which the second law of thermodynamics does not apply and in which the conversion ratio is equal to unity. As examples, he takes the case of any water-motor and of the water in the atmosphere. T. B.

907. *The Physical Significance of van der Waals' Equation.* **J. H. Jeans.** (Chem. Soc., J. 123. pp. 3398–3414, Dec., 1923. The van der Waals Memorial Lecture.)—An epitome of the work that lead up to the enunciation of van der Waals' equation and the "law of corresponding states." The significance of the constants *a* and *b* is discussed both in the light of van der Waals' knowledge and of modern theory, and further attempts, such as the equations of state due to Dieterici and Clausius are reviewed. The quantity *b* appears to have the significance originally given to it and it is pointed out that the apparent rigidity of molecules, known to be invertebrate structures of electric charges, is inevitable on quantum considerations. The quantity *a* is given a statistical interpretation rather than that of a general molecular attraction as deduced by van der Waals from the Joule-Thomson effect. A. Wh.

908. *The Value of "b" in van der Waals' Equation.* **W. Herz.** (Zeits. Elektrochem. 29. pp. 527–530, Nov., 1923.)—There should be a proportionality between b_K and M/d_K (where M = mol-weight and d_K = critical density), but this does not appear to have been investigated. The recent appearance of a new edition of Landolt-Bornstein's tables and the experimental investigation on critical data undertaken by the author in conjunction with E. Neukirch (1923) gave him an opportunity to investigate the above-mentioned ratio. The calculation of b_K was made from the expression $b_K = RT_K/8p_K$. The data used for ozone were those obtained by E. H. Riesenfeld [Abstract 1671 (1923)]. The author has compared b_K with M/d_K for 72 substances, and finds that $b_K/M/d_K$ is in general constant, and has an average value of approximately 2·16. Fifty-eight of these substances have values between 2·0 and 2·4. Eight substances, *viz.* hydrochloric acid, acetonitril, acetic acid, methyl and ethyl alcohols, water, nitric oxide, and ammonia, have very low values. These are all associated liquids, but acetone (also an associated liquid) gives a normal value. Neon, hydrogen, and helium give very high values. The value of the ratio for the inert gases is just over 2, with the exception of neon, where the value is about 2·6 and both b_K and M/d_K have abnormally low values. In homologous series of organic compounds M/d_K increases with the molecular weight and somewhat more rapidly than b_K. Finally the author calculates $M/d_0 \div b_0$ where d_0 = density at abs. zero and b_0 the corresponding value of b, making use of van Laar's relation $b_K/b_0 = 2\gamma$ where $2\gamma - 1 = 0{\cdot}038\sqrt{T_K}$, and tabulates the results for about 25 substances. The ratio is fairly constant. T. B.

909. *On a Supposed Limitation of the Second Law of Thermodynamics.* **E. E. Witmer.** (Phil. Mag. 47. pp. 152–159, Jan., 1924.) —It was shown by Fairbourne [see Abstract 2110 (1922)] on certain assumptions, that if a vessel of suitable shape, *e.g.* a truncated cone open at both ends, be immersed in a gas where the mean free path of the molecules is large compared with the dimensions of the vessel, the molecules will pass through the vessel in one preponderating direction. This result would be contrary to the second law of thermodynamics. A fallacy in the reasoning is pointed out by the present author. In the course of the argument, which is carried out in two dimensions, it was assumed that at any point O in the face of the vessel "molecules will enter equally in all directions throughout 180°." The term "point" in this assumption is misleading, as strictly speaking it is an element of length. Let dx be an element of length, OP the normal directed toward one side, and θ the angle between any direction and OP. Then if dn is the number of molecules crossing dx in directions included between θ and $\theta + d\theta$ in a time dt, then $dn = N \cos \theta dx d\theta dt$ where N is a constant. The false assumption made by Fairbourne is equivalent to the omission of the factor $\cos \theta$ in the above equation. It is then shown that the same number of molecules pass through the vessel upwards as downwards, this number being (for the vessel considered by Fairbourne) $4Nadt$, where a = height of vessel = half diameter of the narrower opening. A general proof is also given which applies to any two-dimensional vessel ABCD, where AB and CD are sides of the vessel, AD and BC being open. T. B.

910. *The Entropy of Diatomic Gases and Rotational Specific Heat.* **R. C. Tolman** and **R. M. Badger.** (Am. Chem. Soc., J. 45. pp. 2277–2285, Oct., 1923.)—The entropy of a diatomic gas at temperatures high enough for the specific heat at constant pressure to have reached

7R/2 is given by the quantum theory as $(7/2)R \log_e T + R \log_e p + 3/2 R \log_e M + R \log_e J + S_2$, where T, p, M, J are temperature, pressure, molecular weight, and moment of inertia, and S_2 is a constant whose value it is the object of the paper to discuss. The calculations are based on the assumption that the entropy can be expressed as the sum of that which a perfect monatomic gas would have, together with that due to the excess of C_p over $\frac{5R}{2}$ from absolute zero upwards. The latter part is shown to be $-\int_0^T R\sigma^2 \frac{d^2}{d\sigma^2} \log Q \, . \, d(\log \sigma)$, where $Q = \epsilon p_m e^{-m^2\sigma}$ and $\sigma = \frac{h^2}{8\pi^2 J k T}$, in which p_m is the *à priori* probability of the "*m*th" quantum state and the summation is over all possible rotational states. This integral is evaluated for six suggested values of p_m, and is found to give values differing by only 5 % at the extremes, so that experimental decision between the theories is extremely difficult. The authors' attempt, however (taking the moments of inertia chiefly from the infra-red spectra), to compare the experimental values of entropy with those calculated by the six formulæ developed, and come to the conclusion that the value of S_2 is most probably $S_1 + R + R \log \frac{4\pi^2 k}{h^2}$, a value given independently by three of the six assumptions as to p_m, including Tolman's own suggestion that the lowest possible azimuthal quantum number is ½. E. G.

911. *On the Thermodynamics of the Ionisation of Monatomic Gases.* **R. Becker.** (Phys. Zeits. 24. p. 485; Disc., 485–486, Nov. 1–15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—When a gas is heated to a sufficiently high temperature, its atoms are partly in a variety of dynamic states, and partly ionised by complete separation of an electron. The present considerations are restricted to the activity of one electron, conditions which are realised with H atoms and the vapours of alkali elements. This notice contains a brief summary of the complete account given in the Zeits. f. Physik [see Abstract 575 (1924)] together with an abstract of the *discussion* which followed the reading of the paper. In the latter, **Ornstein** discussed the uncertainty of quanta statistics, **Herzfeld** the possible orientations of the atomic axes, **Born** the evaporation of hydrogen and the splitting off of an electron together with the difficulty that the sum of the quantum weights does not converge, **Einstein** the process of derivation of the final formula, and **Nernst** the validity of deduction solely from statistical considerations without application of his heat theorem. H. H. Ho.

SOUND.

912. *Velocity of Sound in Free Air.* **A. McAdie.** (Astron. Obs. of Harvard College Annals, 86. 2. pp. 107–117, 1922.)—The results obtained from various investigations of the velocity of sound are summarised, and variations due to temperature, pressure, humidity, turbulence, and wind are discussed. Values obtained from observations at Blue Hill Observatory at different temperatures and humidities are given. A. W. L.

913. *Velocity of Sound in Moist Air.* **W. R. Barss** and **J. E. Bastille.** (Math. and Phys. J. Massachusetts, 2. pp. 210–215, Dec., 1923.)—Values are found by a resonance method for the velocity of sound in air at ordinary pressure and about 20° C., of humidity varying from 0 to 100 per cent., and are in good agreement with those calculated from the usual theory, assuming that neither the isothermal elasticity nor the ratio of the specific heats varies appreciably with the humidity. G. A. S.

914. *Action of Sound-Waves on a Resonating Membrane.* **E. Meyer.** (Ann. d. Physik, 71. 8. pp. 567–590, June 19, 1923.)—The mutual action of the sound-waves and the membrane investigated; the damping of the membrane calculated; photographic work. Asymmetries investigated. Quantitative data. A. D.

915. *Acoustical Powers in Absolute Units.* **P. E. Sabine.** (Phys. Rev. 22. pp. 303–312, Sept., 1923.)—The late W. C. Sabine showed how the rate of energy emission of a source of a given pitch could be determined in terms of the minimum audible energy density for that pitch. Using this method, and ascertaining for a particular observer the minimum audible energy densities for various pitches by Kranz's method, values are found for the acoustic output in absolute units of various sources. No great degree of precision is claimed for these values, but, in view of the great intrinsic difficulties involved in absolute acoustic measurements, even roughly approximate values are desirable. The power of a violincello when bowed strongly varies from 1000 ergs/sec. at a frequency of 128/sec. to about 10 ergs/sec. at 650/sec. A good violin gives a fairly uniform output of 600 ergs/sec. for frequencies from 192 to 1300/sec. An inferior violin gives a much lower output. Results are also given for 23 organ pipes of pitches ranging from 129 to 3687/sec. For twelve different vowel sounds intoned by a masculine voice at approximately the loudness of ordinary speech and at a frequency of 128/sec. the output of the fundamental was found to be practically constant at 55 ergs/sec. The vowels ah, aw, ō and o͞o have predominating overtones of respective pitches 870, 460, 410 and 330/sec. The corresponding outputs are 225, 200, 32, and 10 ergs/sec. respectively. Some results for a feminine voice are also given. Here the pitch for the fundamental of o͞o rose from 258 to 326 as the loudness was increased to three times conversational.
G. A. S.

916. *Critical Frequency of Pulsation of Tones.* **Mollie Weinberg** and **F. Allen.** (Phil. Mag. 47. pp. 50–62, Jan., 1924.)—The successful application of the principle of the persistence of vision, or the critical frequency of flicker, to the study of problems of colour vision suggested the probable value of the analogous principle of the persistence of audition to the solution of problems of the perception of sound. It is here shown that the method in question is capable of extension to some of the phenomena of physiological acoustics. [See Abstract 1197 (1919).]

The experimental arrangements were similar to those used in the work on colour vision. The source of sound was a Stern tonvariator (a simple König resonator with a movable bottom like a piston) placed inside a box lined with very soft thick felt, through which at a suitable place a hole was cut. The tonvariator was blown by a stream of air from a large constant-pressure tank. The periodic interruption of the continuous sound into separate pulses was effected by the rotation of a motor-driven light aluminium disc with four symmetrically placed holes of the size of that in the box. A speed counter and a clock beating half seconds served to compute the speed of the disc and hence the critical frequency of pulsation, or flutter, of the sound when it became just continuous to the ear. The experiments fall into ten sets each at a specified pressure, these values varying from 1·25 cm. to 2·40 cm. Each set has a number of frequencies from about 142 per second to about 280 per second. The duration of the sound just to lose the sound of pulsation or flutter is found for each frequency and varies from 0·0127 sec. for lowest pressure and highest frequency to 0·0215 sec. for highest pressure and lowest frequency. These results are shown in graphs, the critical duration being plotted against frequency, a separate graph being used for each pressure (which has been shown by Love and Dawson to be proportional to the intensity of sound emitted [Abstract 1418 (1919)]. The law which seems to fit the graphs is written $D = K/\sqrt{\log N} + C$. Where D is critical, duration of sound of frequency N, K, and C being constants. In colour vision Ferry (1892) found for the flicker duration $D = 1/(K \log L)$ where L is the luminosity; and Porter (1902) found $1/D = K \log L + C$; K and C being constants as before. On testing the ears of a number of observers the slopes of the graphs were found to be very nearly the same. E. H. B.

917. *Effect of Aural Fatigue on Critical Frequency of Pulsation of Tones.* **Mollie Weinberg** and **F. Allen.** (Phil. Mag. 47. pp. 126–141, Jan., 1924. Paper read before the Roy. Soc. Canada, May, 1922.)—This work is concerned with the effects of fatigue upon the persistence of audition, or the duration of the tone at the critical frequency of pulsation or flutter. The results throw light upon some phenomena of acoustics, and also upon the probable structure of the aural mechanism, by means of which tones are perceived and differentiated from each other. The apparatus used is that described in the preceding abstract. For fatiguing the ear, another tonvariator was used similar in all respects to that in the sound-proof box. Two methods were used, one the converse of the other, the results from each being of a confirmatory nature. The first method consisted in fatiguing the ear (for two minutes) with a tone of constant frequency and taking measurements over a range of about fifteen above and below the fatiguing frequency. The second method consisted in taking measurements on a tone of constant frequency, and varying the fatiguing stimulus over a similar range of about thirty vibrations per second. It is found that when the fatiguing tone agrees in frequency with that under measurement the fatigue is a maximum. When the frequency of the fatiguing tone is about eight per second above or below that under measurement, the fatigue effect is evanescent. The experiments show that, as a result of fatigue, the persistency of sound impressions is greatly increased. The fatigue effect is marked for only a very few vibrations on each side of the maximum. The general nature of the fatigue curve is the same for each frequency.

These results of aural fatigue are susceptible of explanation by assuming the existence of a resonance mechanism in the ear. Indeed the fatigue curve is of the same type as the Helmholtz response curve as shown in this paper by plotting the two on the same diagram for comparison.

E. H. B.

918. *Effect of Fatiguing the Ear with Combinations of Two or more Tones.* **Mollie Weinberg.** (Phil. Mag. 47. pp. 141–151, Jan., 1924. Paper read before the Roy. Soc. Canada, May, 1923.)—In these experiments the apparatus used for the two previous researches [see preceding abstracts] was modified by enclosing the upper part of the tonvariator in a box made of pressed fibre, a material which (if a quarter of an inch thick) Watson had shown to be incapable of transmitting more than about one-tenth of one per cent. of the sound. On fatiguing the ear by a single tone it was shown before that the result could be expressed by superposing a fatigue curve on the slightly sloping graph coordinating duration of pulsations and frequency. When the ear is now fatigued by two (or more) tones, the results are similarly expressed by superposing two (or more) fatigue curves on the graph for the unfatigued ear. When, however, the two (or more) fatiguing tones are brought nearer together in respect to frequency the two separate fatigue curves, at a certain stage, begin to coalesce, leaving but a shallow trough between them ; till finally the two (or more) crests of the curves coalesce and show but a single peak.

It is concluded that the results of this work support the theory formulated by Helmholtz, that tones are perceived and differentiated from each other by means of a resonance mechanism which exists in the internal ear.

E. H. B.

919. *Tinnitus and Nerve Deafness.* **J. P. Minton.** (Phys. Rev. 22. pp. 506–509, Nov., 1923.)—Patients suffering from tinnitus, or ringing in the ear, show a marked decrease in sensitivity for the range of frequency of the subjective tones. Within this range, but not outside it, there is a decided masking effect. Tinnitus is associated with nerve lesions. These results, therefore, and certain simple experiments with tuning-forks, indicate that the conclusions of Wegel and Lane on the masking of objective tones may not be correct, and that the disturbance is in the nerve system and not in the mechanical system of the inner ear. [See Abstract 2231 (1923).]

G. A. S.

920. *Electrical Apparatus for the Deaf.* **C. M. R. Balbi.** (El. Rev. 94. pp. 87–89, Jan. 18, and pp. 149–150, Jan. 25, 1924.)—Sound waves impinging on the tympanum of the ear (outer ear) set up vibrations which are communicated by a link-work (middle ear) to the inner ear, where the mechanical energy is transformed into nervous energy. If the inner ear is sound and the reception and transmission mechanism are only slightly impaired a simple microphone and receiver, with amplification about 30, will be effectual in enabling ordinary sounds to be heard. A double set with two microphones about 8″ apart and two receivers makes location of a given sound easier. When the transmission mechanism is so far impaired that such an instrument is ineffectual the attempt to enforce hearing by producing louder sounds only tends to increase deafness and set up irritation. The inner ear must be stimulated through some other channel. A small simple instrument weighing four or five ounces is described by which sound vibrations can be transmitted to the inner ear through the bones of the head. Used with a powerful amplifier it enables very deaf persons to hear perfectly. For the less acutely deaf a powerful loud-speaker, which is described, has also been used. Deafness due to defects of the inner ear cannot be overcome by any electrical method.

G. A. S.

921. *Acoustics of the Pianoforte. Part I.* **S. K. Datta.** (Indian Assoc. for Cultivation of Sci., Proc. 8. 2. pp. 107–116, 1923.)—C. V. Raman and B. Banerji obtained the pressure of a rigid hammer on a string by regarding the motion during impact as that of a loaded string. P. Das obtained the solution by the functional method of Kaufmann considering the discontinuous changes in the pressure of the hammer due to the successive reflections of the impulse from the ends of the string. This line being similar to that given by Love for the longitudinal vibrations of a rod struck at the end. By this method the amplitudes of the different harmonics can be determined from the forces. In the present paper these amplitudes are calculated from the equation and then compared with those found experimentally by measurement with a microscope. The very close agreement between the observed and calculated values is a good confirmation of the equation. The observed values are always less than the calculated ones, as should be the case, since in P. Das's theory no account is taken of dissipation of energy, yet some must occur. The paper includes two tables and three graphs. The striking points dealt with are one-ninth and one-tenth, and the first ten partials are treated in each case. [See Abstract 1674 (1922).] E. H. B.

922. *Variable Acoustic Wave Filter.* **G. W. Stewart.** (Phys. Rev. 22. pp. 502–505, Nov., 1923.)—An extension of earlier work [see Abstract 346 (1923)] indicates that if the size of the orifice leading into the side tube is altered, the upper limiting frequency should change while the lower limiting frequency remains constant, thus changing the width of the band. The orifice is readily changed by introducing a cylinder of paper with suitably punched holes. Experimental results confirm the prediction as to the lower limit and give for three different orifices upper limiting frequencies of 455, 390, and 340 per sec., the corresponding theoretical values being 510, 440, and 385 respectively. G. A. S.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

923. *Mutual Mass of Two Electrons.* **E. Persico.** (Accad. Lincei, Atti, 32. ii. pp. 280–286, Nov. 10, 1923.)—Silberstein [Abstract 505 (1911)] calculated the mutual mass of two moving charged spheres for the case where they are wholly external to one another, and where the one is inside the other. The mutual mass is a supplementary term, ±, to be added to the simple sum of the two electromagnetic masses. Calculating from mass = energy/c^2, different results are obtained. But, the author shows, these results can be harmonised by assuming that the external force does not exactly balance the electromagnetic force with which the field of the two charges reacts on the charges themselves. A. D.

924. *Electrostatic Fields of Gauzes and Diaphragms.* **A. Walther** and **Lydia Inge.** (Zeits. f. Physik, 19. 3. pp. 192–205, 1923.)—Experimental confirmation of Semenoff's conclusions [Abstract 124 (1924)] that there is a source of error in assuming that electrons come to the same potential as the gauze. The error may amount to 1 per cent. with gauzes, but is much smaller with diaphragms. A. D.

DISCHARGE AND OSCILLATIONS.

925. *Effect of the Gauze in the Franck Modification of the Rutherford Alternating-Current Method for Measuring Ionic Mobilities.* **L. B. Loeb.** (Frank. Inst. J. 196. pp. 771–778, Dec., 1923.)—In a previous paper [Abstract 597 (1924)] it was shown that the apparent mobility of the negative ions, as given by the Franck modification of the Rutherford alternating-current method varied through large limits as the auxiliary field strength G was varied. It was further shown that the magnitude of this effect indicated rather an instrumental effect of the gauze than a change in the nature of the ion with time. It is the purpose of this paper to show just how this instrumental effect of the gauze must change the value of the mobility found by its use. An extensive series of measurements is made on the mobilities of the ions changing the values of the auxiliary field G, the value of the alternating field at which the ions just cross E_0, and the frequency of the alternating field, but maintaining all other conditions the same. The results obtained are summarised as follows: For $E_0/G = A$ less than unity the mobility of the ions lies above 2·15 cm./sec., and increases slowly as A is decreased to a value of 2·35 cm./sec. at A = 0·08. For A greater than unity the mobility lies below 2·15, and decreases almost linearly as $\log_{10} A$ increases down to a value of 1·66 at A = 55·0. At values of A about unity the mobility curves make sharp intercepts with the voltage axis. As A decreases they remain fairly well defined, except at the lowest values of A used where there is a distinct tendency for these intercepts to develop asymptotic feet. As A increases the intercepts become rapidly more and more rounded until at the point where A = 55 it becomes almost impossible to pick a definite intercept of the mobility curve with the axis. For high values of G the current does not fall to 0 below E_0, but attains a constant value equal to the current observed when E is 0. The magnitude of this current increases as G increases. For lower values of G the ion current falls to 0 below E_0 and remains there. At the lowest values of G the current below E_0 reverses in sign and increases in magnitude as G decreases. The reversed current is in all cases small compared to the currents in the opposite direction observed with a large G. If the max. possible current to the electrometer plate at a fixed field strength E is designated as I_0, and the average current in a time T as I, then it is found on comparing the computed and observed I/I_0 curves for different values of A that for values of A greater than unity the observed curves fall markedly below the computed ones, while for values of A below unity the two curves coincide in a satisfactory manner except for the lowest values attained, where the observed curves rise very slightly above the computed ones. In the extreme case $A = 87$, the observed I/I_0 is only one-third the computed curve; this is because with the relatively high alternating field only a fraction of the ions that are available reach the field E, and hence the upper plate. An explanation of these effects is made on the assumption that a phenomenon occurs which has been found to occur in the use of gauzes or grids in other experiments, *viz.* the penetration of fields through the gauze. It is pointed out that when the value of A approaches unity the conditions are essentially fulfilled for determining the true value of the mobility of the negative ions, for under these circumstances the computed and observed I/I_0 curves coincide. The value of the negative ion mobility obtained at this point lies close to 2·20 cm./sec., which agrees with the value found for the negative ions without the use of the gauze. A. E. G.

926. *The Velocity of Thermions from Alkaline Earths.* **M. Rössiger.** (Zeits. f. Physik, 19. 3. pp. 167–191, 1923.)—Mathematical and experimental study of the movement of electrons between a glowing filament and a co-axial cylindrical anode under the influence of an accelerating potential-difference and a magnetic field parallel to the axis. In four series of experiments of different type the accuracy of Maxwell's law for distribution of velocities was confirmed for thermions from BaO, SrO, CaO. A. D.

927. *The Thermionic and Photoelectric Properties of the Electro-Positive Metals.* **A. F. A. Young.** (Roy. Soc., Proc. 104. pp. 611–639, Dec., 1923.)—The magnitude of the purely thermal emission of electrons from the alkali metals has not been fully determined as yet. In Richardson's work on the emission from sodium [see Abstract 1489 (1904)] the conditions were such that there was a considerable evolution of gas in the apparatus during the heating, and the currents obtained showed no approach to saturation. Fredenhagen's work is briefly summarised, in which the conclusion was drawn that the observed currents were not due to the metal itself, but to some gas which could be partly removed by repeated distillation of the metal. Fredenhagen also concluded that the gas was probably hydrogen, although he had no direct proof. In the present work a fresh attempt is made to determine the magnitude of the thermionic emission from the alkali metals. Observations have also been made on the photoelectric emission with regard to the threshold frequency. The experimental arrangements are very fully described. Sodium was found not to give a measurable thermionic emission (*i.e.* greater than 10^{-10} amps.) for temperatures up to 390° C. Potassium was found to give currents measurable in some cases by an electroscope at temperatures down to that of the room. The currents are believed to be of thermionic origin, and not due to chemical reaction. The values of *b* for potassium in the emission formula, $i = A_1 \epsilon T^{\frac{1}{2}} \varepsilon^{-b/T}$, were found lower than any others, yet obtained with other metals, and the values of A_1 were also low. The change of state of the potassium from solid to liquid or *vice versa* made no difference in the magnitude of the thermionic current, or in the value of the constant *b*. Determinations of the photoelectric work function ϕ_0 from photoelectric measurements, made at the same time as the thermionic measurements and at nearly the same temperature, showed that ϕ_0 was always a good deal greater than the thermionic work function ϕ calculated from the values of *b*. Richardson has suggested as an explanation of this difference that the thermionic current comes chiefly from those parts of the surface which have the smallest value of the work function, while the photoelectric current is more evenly distributed over the whole surface, a measurable amount coming also from those parts which have the higher values of the work function. This theory is the subject of further measurements. H. H. Ho.

928. *A New Photoelectric Effect. Reflection of Electrons Induced by Light.* **I. Langmuir.** (Science, 58. pp. 398–400, Nov. 16, 1923.)—A study of some vacuum tubes containing cæsium vapour has shown a peculiar photoelectric effect. The action of white light on an adsorbed film of cæsium on nickel seems to cause this surface to reflect elastically, electrons which are made to impinge on it. The number of electrons then can be thus reflected is found to be proportional to the intensity of the light. Experimental details are given with data. A sharp distinction between the new photo effect and the normal effect is that the former disappears entirely if a piece of red glass is interposed in front of the light source. It is probable that the effect is mainly due to light having a wave-length of about 5300 Å. (blue-green). A similar activation of a nickel surface causing electron reflection has also been found in connection with some measurements of the distribution of velocities of electrons in the positive column of the mercury-arc, by the method of measuring positive ion currents (Science, 58. 290, 1923). By introducing high-speed electrons (40 volts) into the mercury arc by means of a heated negatively charged tungsten filament, it was found that the ability of a small collecting electrode (1 sq. cm. area) to take up low-speed electrons was greatly impaired. H. H. Ho.

929. *Motions of Electrons in Gases and the Formation of Negative Ions in Air.* **L. B. Loeb.** (Phil. Mag. 46. pp. 1088–1089, Dec., 1923.)—This is an answer to the recent note of V. A. Bailey [see Abstract 2242 (1923)] commenting on the writer's work reported in 1921 [see Abstract 984, (1922)]. It is claimed that the writer did not use the method termed by Bailey the "Franck modification," which involves the use of an alternating current of sinusoidal form. As the result of more careful measurements, using the square wave oscillations, it is now considered an open question whether the rigorous form of the Thomson theory is correct or not. It is agreed that the use of sinusoidal alternating potentials of high frequency for the measurement of electron mobilities is unsatisfactory, but that up to the present that method has furnished the only means of estimating the electron mobilities in most gases above 100 mm. pressure. A. E. G.

930. *Motion of Electrons in Gases.* **V. A. Bailey.** (Phil. Mag. 46. pp. 1090–1091, Dec., 1923.)—A reply to Loeb's note [see preceding abstract]. As Loeb used high-frequency oscillations from an audion oscillator which involves the use of an alternating current of sinusoidal form, the objections he raises towards the writer's statements as to the methods employed by Loeb do not appear well founded. The statement of Loeb that electron "mobilities" by means of sinusoidal alternating potentials has up to the present furnished the only means of estimating electron mobilities in most gases above 100 mm. pressure is objected to, and Townend's method involving the magnetic deflection of a stream of electrons moving in a uniform electric field is cited as another method. A. E. G.

931. *Electro-Sensitive Laminæ.* **G. Piaggesi.** (N. Cimento, 26. pp. 45–67, July–Aug.–Sept., 1923.)—Prati (L'Arduo, June 1921, Bologna) found that films of colophonium were altered by the impact of ions, so that electric shadows could be produced. The author has prepared a variety of more sensitive films by oxidation of oils, etc. The shadows produced demonstrate the mutual repulsion of homonomous fluxes of ions. A. D.

932. *Variations of Thermionic Current in Hydrogen at Low Pressure.* **M. Laporte.** (J. de Physique et le Radium, 4. pp. 370–375, Oct., 1923.) —The apparatus used was a quartz tube with central tungsten filament surrounded by a molybdenum cylinder. The tube was evacuated and washed out many times with pure dry hydrogen, while the filament was kept incandescent. Experiments were carried out for a pressure range from 10^{-4} to $0 \cdot 8$ mm. of mercury. Different results were obtained for potentials less and greater than the ionising potential of hydrogen. With small potentials, *e.g.* 7 volts, the electronic current between filament and anode is greatest for the highest vacuum and falls as the pressure increases at higher voltages than the ionising potential, *e.g.* 18 volts, the current increases at first slowly with the pressure, then jumps, and afterwards decreases. For intermediate voltages a whole series of intermediate curves may be obtained. From these it is possible to select the pressure conditions which will result in the commencement of ionisation being as sharply marked as possible. Theoretical considerations, with certain assumptions, lead to the conclusion that the most favourable pressure is such that the mean free path of the electron is equal to the distance from the filament to the surrounding cylinder. Calculation for the apparatus used gave a value of $0 \cdot 17$ mm. of mercury for the most favourable pressure, but experiment gave the value $0 \cdot 08$ mm. A. W.

933. *Ionisation; Quinine Sulphate.* **F. Harms.** (Ann. d. Physik, 73. 3–4. pp. 237–241, Jan., 1924.)—Quinine sulphate emits ions when being dried by heat, and also when the dried mass is cooling down. There appear to be two stable compounds, the dry and the slightly hydrated. A. D.

934. *Ionising Potentials of Helium and Some Multi-Atomic Gases.* **C. A. Mackay.** (Phil. Mag. 46. pp. 828–835, Nov., 1923.)—Using the method employed by Hughes and Dixon [Abstract 191 (1918)] the author has determined the ionising potentials of helium, HCl, HBr, HI, H_2O, NH_3, H_2, N_2, and O_2, the observed values being respectively 24·5, 13·8, 13·2, 12·8, 13·2, 11·1, 15·8, 16·3, and 12·5 volts. These values are in good agreement with theoretical estimates (Born and Fajans), and with the experimental results of other observers. The work is to be extended to other multi-atomic gases. A. B. W.

935. *The Excitation and Ionisation Potentials of Gases and Vapours.* **F. Horton.** (Phys. Soc., Proc. 36. pp. 1–13, Dec., 1923.)—The minimum difference of potential through which an electron must fall in order to acquire sufficient energy to enable it to ionise a normal atom on collision with it is called the *ionisation potential* for the atom. Similarly the minimum p.d. which will give to the colliding electron sufficient energy to enable it to displace one of the outer electrons of the atomic structure from its normal orbit to some other orbit within the atom is termed the *excitation potential* for the atom. The recognition of the possibility of the existence of excitation potentials is due to Bohr, and arises directly from his theory of atomic structure. Thus, in accordance with Bohr's theory, we may expect for all atoms excitation potentials which are smaller than the corresponding ionisation potentials, and the recombination which follows the ionisation of a mass of gas should give rise to all the radiations of the arc system. The methods by which the excitation potential may be measured can be divided into two classes: (*a*) Those methods which depend on the detection of a loss of energy by the colliding electron. (*b*) Those methods which depend on the detection of the radiation resulting from the collision. The method of testing for the occurrence of inelastic collisions has been largely used by the American experimenters, Tate, Foote, Meggers, and Mohler. The principle of this method is described in detail, as is also that of the spectroscopic method. The observed values of the excitation and ionisation potentials in the case of potassium are 1·55 volts and 4·1 volts respectively, in good agreement with the values 1·61 and 4·32 volts calculated by the quantum relation from the frequencies of the first and last lines of the series $1\sigma - m\pi$. In the case of magnesium, excitation potentials were found at 2·65 volts and at 4·42 volts, and ionisation was found to begin at 7·75 volts. The spectroscopic investigation showed a single line only (corresponding to the excitation potential 2·65 volts) for voltages between 2·65 and 4·42; a two-line spectrum (the lines corresponding to 2·65 volts and 4·42 volts) for voltages between 4·42 and the ionisation value 7·61. The cases of the simple atoms H and He are discussed in detail. The considerations here put forward illustrate the importance of an accurate knowledge of the excitation and ionisation potentials of different elements as a direct experimental test of the correctness of various atomic models, particularly in those cases for which the easily photographed optical spectra are not associated with the normal conditions of the atom in question [see also Abstracts 537 and 539 (1923)]. A. E. G.

936. *Velocity of Positive Ions in the Crookes Dark Space.* **F. W. Aston.** (Roy. Soc., Proc. 104. pp. 565–571, Dec., 1923.)—The nature of the negative glow and the mechanism by which the current is carried across the Crookes dark space at moderately low pressures are still matters of speculation. In a previous paper [see Abstract 487 (1913)] the author drew attention to the difficulties in the way of formulating a workable theory. One of these difficulties was an apparently hopeless discrepancy between two values for the velocities of the positive ions at the surface of the kathode, the one calculated from their measured space charge and the total current passing through the tube, the other obtained by extrapolation from the mobility measured at higher pressures. It is now recognised that the latter value was definitely wrong, and in this paper it is shown that if instead the velocity is calculated from more reasonable assumptions the discrepancy is almost entirely removed. If m is the mass and e the charge of the ion moving in a field X_1 the mean rate of progress k_λ towards the kathode will be given by $k_\lambda = \frac{1}{2}\sqrt{2eX\lambda/m}$, where λ is the mean distance moved towards the kathode between two successive collisions. This distance will be somewhat greater than the ordinary " mean free path " of the molecule, on account of the high speed, but will be reduced by the fact that the particle is charged. It is not therefore far wrong to take for λ the ordinary molecular mean free path at the pressure concerned. The mean velocity of the positive ions towards the kathode may also be estimated in a totally different way from considerations of the total charge they bring to it. If ρ is the density of positive electrification on the ions just in front of the kathode, and i the current carried by them to each sq. cm. of its surface, then their mean velocity k_ρ will be given by $k_\rho = i/\rho$. If i be given the value of the total current passing in the discharge, a max. value is obtained for k_ρ, and for comparisons made in this paper that value is used. In the tables given it is shown that the two sets of values for the velocities, calculated so differently, are not only of the same order, but in some numerical agreement, notwithstanding the fact that the masses vary over a range of more than 60 to 1. In all the monatomic gases k_λ is greater than k_ρ, while in the diatomic ones the reverse is the case. This difference would be removed to some extent by the assumption of a smaller value of m, since it is quite certain that a considerable percentage of the current in diatomic gases is carried by atoms. It appears exceedingly probable that a certain percentage of positive ions formed in the negative glow actually do reach the kathode with the full velocity corresponding to a free fall. At lower pressures this has been experimentally demonstrated by positive-ray analysis. On the other hand, the figures here quoted indicate that a much larger proportion reach the kathode with velocities ranged about that derived from a free fall between successive collisions. A. E. G.

937. *The Centres of Light Emission of the Alkalis.* **E. Rupp.** (Ann. d. Physik, 72. 1-2. pp. 1-15, Dec., 1923.)—The nature of the carriers of the light emission from lithium, sodium, and potassium was investigated by examining the anode rays by Wien's method. The apparatus consisted of an exciting chamber of the anode rays connected by an earthed metal piece, pierced by a canal, with the observation chamber. The salt preparation was placed at the end of a glass tube projecting into the exciting chamber and containing a conductor by which the current exciting the anode rays was conveyed. This exciting current was produced by a 20-plate influence machine, and was usually at the potential of 15,000 volts. According to the vacuum in the observation chamber there is distinguished : (1) *Decay Luminosity.*—The atom is excited to luminosity in the canal and gives up in the high vacuum observation chamber its light quantum undisturbed by other atoms. (2) *Luminosity of Change of*

Charge.—Moving atoms are excited to luminosity partially in the canal, but also in the less highly evacuated observation chamber, and give up light quanta frequently not undisturbed by other atoms. The vacuum used in the observation chamber was for the decay luminosity 0·0002–0·0005 mm. Hg, for the luminosity of change of charge 0·002–0·008 mm. Hg. The lines measured by the spectrograph in the different luminosities, when deflected and undeflected, are given. From the observations it appears that: (1) The principal series of the alkali arc spectrum is emitted by an atom which before the emission (changed charge luminosity) and during the emission (decay luminosity) is neutral. (2) The I. and II. subordinate series of the alkali arc spectrum are emitted by atoms which before the emission are positively charged, during the emission are neutral. (3) The spark lines of oxygen are emitted by atoms which before and during the emission are positively charged. The following may be pictured as what occurs to the moving atom: The anode rays leave the anode as positive unloaded ions. On the way to the canal they may experience transfer of charge. The cases of the change effect of the atoms in the canal which lead to light emission may be summed up as follows: (1) Moving neutral atoms strike against neutral or positively (or negatively) charged atoms at rest, or moving with velocity small compared with that of the atoms of the rays. *Excitation of the Principal Series.*—This case is the most frequent. (2) Moving positively charged atoms strike neutral (or negatively charged) atoms, take up thereby an electron, and are thus excited to *emission of the subordinate series*; in the state of emission they are thus neutral. This case is less frequent than the first. (3) Moving positive atoms strike positively charged atoms. *Excitation of the Spark Spectrum.*—This case appears to occur the least frequently with anode rays. Thus in general excitation to light emission of the positive mass rays takes place only through interchange action between moving atoms and atoms relatively at rest. J. J. S.

938. *The Relation between the Potential for Glow-Discharge in Air and the Distribution of the Electric Field round Electrodes of any Form.* **L. Dreyfuss.** (Schweiz. Elektrot. Verein, Bull. 14. pp. 670–678, Dec., 1923.)—The author shows, by test data and theoretical considerations, that in an electrostatic field in air, the fall of potential per unit length along the lines of force may be represented as a simple function of the thickness of the luminous layer. This holds good whatever the form of the electrodes. The normal breakdown strength of the dielectric, measured in a homogeneous field with a large gap, must be exceeded within a certain distance x_0 of the most highly stressed point of the electrode before the first glow can commence. The so-called "surface voltage," *i.e.* the voltage drop Δv in the "ionisation zone" x_0, is then a measure of the field concentration. If the surface voltage exceeds a certain critical value glow discharge occurs. In the first part of this paper the author reproduces the results of investigations by other workers concerning the breakdown strength of air between parallel plate electrodes, and at the surface of cylindrical conductors; he also gives the results of a new series of tests concerning the glow discharge from electrodes with sector-shaped sections of different angles. Within the limits of experimental error, all three sets of data may be represented by a single curve $\Delta v = f(x_0)$. In other words the "surface voltage" as defined above is mainly, if not entirely, a function of the ionisation zone x_0 and not of the form of the electrode.

Knowing the field distribution in the neighbourhood of the most highly stressed part of any electrode, it is possible to calculate the glow-discharge voltage by aid of the curve $\Delta v = f(x_0)$, which is given in the original paper. It is not necessary to make a complete series of measurements for each different form of electrode. Further experimental investigation is required to decide whether the critical voltage for electrodes under oil can be determined in similar manner from the results of a few tests made to obtain, once for all, the relation between surface voltage and ionisation zone. R. E. N.

939. *Emission of Secondary Electrons from Metals under Electronic Bombardment.* **F. Horton and (Miss) A. C. Davies.** (Phil. Mag. 47. pp. 245–249, Jan., 1924.)—The authors continue the discussion with E. W. B. Gill on the interpretation of their experiments [see Abstracts 719 (1920), 2244 (1923), and next abstract]. The authors do not consider that it was necessary to use grid potentials up to 600 volts when investigating a critical potential known to be less than 15 volts; the description of their experiments gives no justification for the statement that only one value of V_G was used. What was deduced from the authors' curves was that the excitation of secondary emission required an applied potential difference between 10 and 11 volts; a correction must be added to get the voltage equivalent of the velocity of impact of the primary electrons on the plate, estimated at 13 volts. The estimate of 9 volts as the maximum velocity of emission of the secondary electrons could only be considered unreliable if it could be shown that the current-potential difference curves, from which it obtained, were a distortion of the true relations between the plate current and the electric field near the plate, such as would be obtained if the screening of the plate by the grid were very inadequate; the experiments, however, have proved that it is almost perfect. Gill's argument would lead to the assumption that, when the potential difference between the grid and the plate is increased beyond 9 volts, the current carried by the secondary electrons leaving the plate suddenly begins to increase, instead of continuing to decrease, with the increase of the field tending to prevent electrons leaving the plate. It appears that there is no appreciable number of secondary electrons leaving the plate with velocities greater than that corresponding to a potential difference of about 9 volts. The most reasonable interpretation of the junction of the two parts of the curve at 9 volts is that the secondary emission practically ceases at this stage, because the velocity of emission of the fastest secondary electrons from platinum corresponds to a potential difference of this value; this estimate, like the other conclusions drawn by the authors from their experiments, is in general agreement with all the most recent work on the subject. H. N. A.

940. *Emission of Secondary Electrons from Metals under Electronic Bombardment.* **E. W. B. Gill.** (Phil. Mag. 46. pp. 994–999, Nov., 1923.) —In a previous paper [Abstract 2243 (1923)] the author gave an account of the secondary emission from the nickel plate of a three-electrode valve, and criticised certain conclusions arrived at by Horton and Davies [Abstract 2244 (1923)]. The subject is further considered in the present paper with particular reference to the action of the grid in modifying the results obtained. It is claimed that the potential of the grid exerts a very important influence on the plate current-voltage curve. A. B. W.

941. *The Dependence of Electron Emission on the Gas Charge of the Metal.* **R. Suhrmann.** (Zeits. techn. Physik, 4. 9. pp. 304–313, 1923.)—The following are the chief points dealt with in this paper: The influence of the gas on the normal and selective photoelectric effect; the effect of the outer and inner gas charging of the metal upon the thermionic emission; the nature of the gas influence; the influence of the outer and inner gas charging on other kinds of electron emission; the active gas. [See Abstract 1651 (1923).] A. E. G.

942. *Free Paths of Slow Electrons in Mercury and Cadmium.* **R. Minkowski.** (Zeits. f. Physik, 18. 5. pp. 258–262, 1923.)—The author finds that the mean free path increases continuously to a velocity between 0 and 0·1 volts. A. D.

943. *Free Paths of Slow Electrons in Argon, etc.* **H. Sponer.** (Zeits. f. Physik, 18. 5. pp. 249–257, 1923.)—In argon, crypton, and xenon the mean free path increases continuously down to a velocity between 0 and 0·1 volt. Minkowski obtains similar results for mercury and cadmium [see preceding abstract], but in smaller degree. Compare C. Ramsauer [Abstract 1494 (1922)]. A. D.

944. *The Normal Kathode-Fall in Air.* **A. Schaufelberger.** (Ann. d. Physik, 73. 1–2. pp. 21–53, Dec., 1923.)—After considering the definition of kathode-fall, a detailed description of the apparatus employed is given. Results obtained show that the measurements made with sounds in the negative glow depend essentially on the build and form of the sound, and so, only with one and the same sound can reproducible results be obtained. The method of drying described gives good reproducible highest values of the kathode-fall. Under these conditions the kathode-fall for 17 different metals in dry air are measured. The measurements of the photographs obtained of the glow-light with the different metals show that, with metals with higher kathode-fall, in general a greater thickness of glow-light is present. A. E. G.

945. *Multiple Glow in Vacuum Tubes.* **R. Seeliger** and **G. Mierdel.** (Zeits. f. Physik, 19. 4. pp. 230–241, 1923.)—The formation of the luminous glow is ascribed to the action of primary electrons from the kathode and secondary electrons produced by collisions within the glow. The inner part of the glow (nearer the kathode) is different from the outer part called the aureole; in the inner part the light emission is excited by both fast and slow electrons, in the aureole by slow ones alone. The glow from four tubes was examined by means of a spectrograph; the first tube contained He + 1/10 per cent. Ne, the second also He + Ne, the third He + Hg, and the fourth He + 2 per cent. Ar. With tubes 1, 3, and 4, He lines were observed in the inner layer, and Ne, Hg, and Ar lines in both parts of the glow. A change of colour took place in the glow from the first tube, a tile-red aureole changing, after continued use of the tube, to violet; with the red aureole the tension was about 180 volts, rising with prolonged use to 250 volts when the violet aureole appeared. The second tube had been supplied with the purest helium and neon; its spectrogram gave He lines in the inner layer and He_2 bands in the aureole; Ne lines were present in both parts of the glow. The non-appearance of the He_2 bands in the inner layer is due to the fact that the excited He atoms are prevented from forming molecules owing to the large quantity of free slow electrons present. Experiments on the effect of impurities and of pressure on the formation of the aureole are also described. It is considered that the presence of small quantities of electro-negative gases will prevent the formation of the aureole. [See also Abstracts 1279 (1920) and 603 (1921).] G. E. A.

946. *The Kathode Temperature in the Glow Discharge of the Inert Gases.* **A. Rüttenauer.** (Zeits. f. Physik, 19. 2. pp. 124–127, 1923.)—This paper describes measurements of kathode temperatures in the Osram "glimmer lamp" (*i.e.* of the Osglim type) when filled with helium, neon, and argon, and discusses their dependence on watt consumption and pressure. To the kathode cap of the valve was affixed a thermoelement consisting of a junction of iron and constantan wires, while the second junction was placed outside the lamp at the end of a glass tube sealed to the lamp. This thermoelement was suitably adjusted for each lamp. Up to 4 watts a linear temperature relation holds, but above this consumption small values for kathode temperatures are recorded. Since the thermal conductivity increases with pressure, a decline in temperature would be anticipated at increased pressures, but actually a small increase has been obtained. This has been established as due to the sharper definition and smaller thickness of the negative glow light at the higher pressure. This is in accord with Hodgson's result that the kathode temperatures in air, oxygen, and carbon dioxide exhibit a minimum at about 1 mm. Hg, and rise very slowly with increasing pressure. The last section of the paper deals with the influence of impurities on the kathode temperature. The greater the differences between the thermal capacities of the filling gases and of the impurities to hand, the greater the influence of the latter on the kathode temperature. Argon is conspicuous in this respect, neon less so, and helium not at all. This affords an excellent criterion for the purity of argon. The paper concludes with a discussion of the connection between the kathode temperature and the characteristic hysteresis of glow-light tubes. H. H. Ho.

947. *Pressure Effect and other Phenomena in Gaseous Discharges.* **I. Langmuir.** (Frank. Inst., J. 196. pp. 751–762, Dec., 1923.)—When an electric discharge of rather high current-density is passed through a monatomic gas at low pressure the gas tends to move towards the anode and causes the pressure at the anode to exceed that at the kathode. This pressure effect has been studied by L. Hamburger, F. Skaupy, and A. Rüttenauer. Hamburger and Skaupy have attempted to explain the motion of the gas to the anode by assuming the presence of negative ions having a mobility higher than that of the positive ions. Skaupy, in a later paper, considers that the effect may be due to the fact that electrons make elastic collisions with atoms, while positive ions make inelastic collisions. Thus he assumes that the electrons deliver twice their momentum to gas molecules, while the positive ions cannot deliver more momentum than corresponds to their velocity. There is a fallacy in this argument, since the rebounding electrons would subsequently collide with other atoms and thus deliver momentum in the opposite direction. In the present paper it is shown that in the positive column of the mercury-arc the electrons have velocities distributed in accord with Maxwell's law, and the directions of motion are distributed nearly at random. The average velocity of the electrons is approximately independent of the arc current, but depends on the pressure. The average kinetic energy of the electrons, expressed in terms of corresponding voltage is 3·9 volts at 1 bar pressure, 2·9 at 4·4 bars, and 1·7 at 33 bars. Isolated electrodes, or glass surfaces, in the uniformly ionised gas of the arc become charged 5 to 15 volts negatively with respect to the gas. The wall of the tube thus absorbs all positive ions moving towards it, but repels all but a minute fraction of the electrons, so that these act largely as if specularly reflected from the wall without loss of energy. The impact of the positive ions on the wall causes a heating effect on the wall which ranges from 15 to 50 per cent. of the total energy in the positive column. The momentum delivered to the wall by the ions is the probable cause of the pressure effect observed by Hamburger and Skaupy by which the pressure of the gas near the anode is greater than at the kathode. Equations are derived by which this pressure effect may be calculated. The results are in rough agreement with experimental data available. Two methods are described for measuring the space potential in ionised gases. The first consists in the use of a hot sounding electrode whose potential is adjusted until the electrons emitted by it are just able to escape. The second is based upon a kink observed in a semi-logarithmic plot of the current voltage curve of a cold sounding electrode, which occurs when the electrode reaches the same potential as the surrounding space. A. E. G.

948. *Researches upon the Disruptive Potential in Rarefied Gases.* **E. Dubois.** (Ann. de Physique, 20. pp. 113–238, Sept.–Oct., 1923.)—The present investigation has had for its object the derivation of the conditions under which this potential exists, and a study of its variation with the nature of the electrodes. Chapter I gives a general discussion of the disruptive discharge. Chapter II is devoted to an examination of the characteristic curves of the discharge current, particularly in the vicinity of the disruptive potential. The ascending branches of the curves are only of importance in the latter respect, since the descending branches do not correspond to the passage of a continuous current. Actually a series of discharges from the electrodes are produced in the gas, which thus play the *rôle* of a condenser of feeble capacity. From the results obtained, a method for the determination of the disruptive potential has been deduced, which is very accurate, easy to employ, and has accordingly been utilised in the present investigation. Chapter III considers measurements of the disruptive potential in hydrogen, where considerable variations were found. These were also discovered to be produced by heating the electrodes, and the author has assigned the cause as due to a transformation at the electrodes. The state of the kathode, however, proved to be the important factor, while the state of the anode appeared to be without influence on the disruptive potential. The cause of the transformation was traced to the disappearance of saline impurities which always exist at the surface of a metal, and these by emitting electric charges occasion a lowering of the disruptive potential of the system. An attempt to find whether substances other than saline impurities would produce the same emission, showed that the action, say, of occluded gas in the electrodes was negligible as compared with that of saline impurities. In the particular case of a palladium kathode, however, the disruptive potential was lowered considerably by the presence of a large amount of hydrogen in it. Similar results have been found qualitatively for carbon dioxide and air. Chapter IV describes certain applications of the preceding results; since all previous data are now rendered invalid because of failure to take account of saline impurities. These errors are much more considerable than effects due to pressure changes, and may range from 20 to 100 %. The experimental data are then utilised in a discussion of the current theory of the disruptive potential which is strengthened thereby, and requires but slight modification, since, in addition to charges originating in the gas, there are supplementary emissions from the kathode. The variations of the disruptive potential with the state of the electrodes are compared with variations already observed by Warburg relating to the kathode fall of potential. These variations are also intimately connected with the emission of positive electricity by incandescent bodies, and the author has shown that the comparison of the two phenomena permits an explanation of certain peculiarities of the positive emission. H. H. Ho.

949. *The Mobilities of Electrons in Air.* **L. B. Loeb.** (Nat. Acad. Sci., Proc. 9. pp. 335–340, Oct., 1923.)—In previous publications [see Abstract 195 (1923)] the author has shown that electrons in gases at atmospheric pressure have rather high mobilities, which vary with the field strength, and that J. J. Thomson's theory of negative ion formation is qualitatively adequate to explain the phenomena observed. To obtain a quantitative verification of this theory it is essential to measure the mobilities of electrons in air at pressures above 40 mm., and the determination of such mobilities appeared at one time impossible owing to the attachment of the electrons to the oxygen molecules to form ions. It was shown, however, that by neutralising the field produced by an accumulation of the ions, and perhaps in a measure preventing its formation, by the use of a constant retarding field superposed upon the alternating field, it was possible to measure mobilities of an electronic magnitude in air. The results are now recorded together with the related experimental details. Curves are given for the values of k (the mobility constant) obtained for the range of frequencies available for pressures of 41, 51·5, 60, 66·5, and 92 mm. of Hg, plotted as points against the voltage $V = E_0 - R$. These show that the values of k as a function of V at different pressures do not fall into a family of curves as is the case for the electrons in H_2 and N_2. The cause for this peculiar behaviour is unaccounted for by the theory, and may be due to the effect of attachments. Bends in the curves mark the beginning of the average attachment. Equations are given finally for the true electron mobility constant at the above pressures. H. H. Ho.

950. *Disruptive Potential and Paschen's Law.* **R. Rudy.** (Rev. Gén. d'Él. 14. pp. 691–696, Nov. 10, 1923.)—Paschen's law enunciates that the difference of potential between two plates depends solely, for a particular gas, on the product of the distance between the plates and the pressure of the gas. If two metallic discs are placed in a gas ionised by an outside agency, and there is a difference of potential V, the ions are attracted towards the plates and travel more rapidly as the field is intensified. At a certain tension the current increases less rapidly and ceases to augment, when the field is sufficiently strong to attract all the ions to the plates in proportion as the ionising source produces them in the gaseous mixture. If, however, the tension is still further raised, a third state of the current appears, wherein the intensity grows very rapidly with the difference of potential, until the disruptive discharge is produced in some form or other. The author proceeds to prove Paschen's law mathematically and emphasises the point that the variations to this law can only proceed from an exchange of energy by quanta and are consequently due to a modification of the molecule under the effect of pressure. These variations also depend equally on the number of ions produced by an electron and a positive ion in a length of one cm. of their travel. If a portion of the molecules is modified, *i.e.* if the electrons which form the surface have been displaced or detached by the influence of molecular collision or under the action of radiation, the absorption of the gas will diminish proportionally to this number of molecules when the gas is compressed. This is particularly so in the case of CO_2 compressed to from 10 to 50 atmospheres. The conductivity of a gas appears to be greatly raised as it approaches liquefaction, and the spark becomes very large. The number of ions an electron produces depends on its live force which is not necessarily in equilibrium with the kinetic energy of the molecules it meets. The electrons can therefore suffer a great number of shocks with molecules without their final speed corresponding to that of the gas. T. C. H.

951. *Electric Tenacity of Air between Plate Electrodes.* **W. O. Schumann.** (Archiv f. Elektrot. 12. pp. 379–380, Oct. 31, 1923.)—The author replies to criticisms on his experiments previously described, and says that the effect of the margins of the plates was allowed for. The constancy of the disruption field strength in homogeneous fields cannot be upheld, and is only to be understood through the survival of obsolete analogies with mechanical tenacity. For gases the ionisation process has long been known as cause of the disruption, and it would be surprising if the measurements should show a constant disruption field strength. J. J. S.

952. *The Sparking-Potential of Gases.* **G. Holst and E. Oosterhuis.** (Phil. Mag. 46. pp. 1117–1122, Dec., 1923.)—In his paper "Ionisation by Collision," J. S. Townsend [see Abstract 1198 (1923)] has discussed a theory of the sparking-potential of gases suggested by the authors in a short note in the Comptes Rendus [see Abstract 352 (1923)]. This theory is based on the assumption that positive ions can liberate electrons from the kathode, no ionisation taking place by the collision of a positive ion against a gas molecule. An account is here given of the considerations and experimental facts underlying this hypothesis. A gas molecule can be ionised by an electron as soon as the energy of the electron reaches a certain value corresponding to the ionisation-potential of the molecule. In order that a positive ion may be able to ionise, it should have at least the same energy. In many cases the conditions in a discharge-tube are such that it is impossible for a positive ion to acquire this energy. The phenomena in neon show a very simple character, and for this reason most of these experiments and considerations relate to neon. If an electric current passes through a tube filled with neon a glow can already be observed at very small currents of the order of magnitude of 10^{-9} amp. The appearance of this glow can give some information about the phenomena going on during the discharge. A neon discharge-tube with electrode distance about 1 cm., gas pressure about 1 cm., is put in series with a diode. By regulating the filament current of the latter the current in the neon tube can be varied from very small values to a value where the kathode glow begins; in this way the successive forms of the discharge are studied. The results obtained lead to the consideration of a hypothetical ideal gas in which an electron loses no energy whatsoever in collisions as long as its velocity is below that corresponding to the ionising potential. An electron will ionise as soon as its velocity is equal to the ionisation potential V_i; n positive ions will liberate one electron at the kathode surface. No positive ion ionises a gas molecule by collision. An electron starts at the kathode. At a distance d from the kathode—where the electron has fallen through a p.d. equal to V_i—it ionises for the first time, forming one new electron and one positive ion. At a distance $2d$ it ionises again, and so on. The total number of positive ions formed is $2^g - 1$, g being the number of times the process is repeated. Sparking will occur when these ions, on reaching the kathode, liberate one electron or more, for in that case the current will continue to flow. As soon as g reaches a value g_s given by the relation $2^{g_s} - 1 > n$, the condition for sparking is reached, the sparking-potential V_s is equal to $g_s V_i$.

For different kathode materials and for different ions, n will be different; n will be larger if it is difficult to extract an electron from the kathode, and thus n will depend on ϕ, the work necessary to liberate an electron from the kathode. For the hypothetical ideal gas the sparking-potential $V_s = g_s V_i$ would be independent of the gas pressure and the electrode distance; it depends only on the ionisation-potential of the gas and on the number of electrons liberated from the kathode by a positive ion. The ideal gas is only a rough first approximation. In a real gas the sparking-potential depends on gas pressure and electrode distance. This is due to the fact that in a real gas energy is lost by collisions. A second approximation is therefore next considered. It is found that even in the case of argon, no formula for V_s can be derived. With helium a new complication is introduced by the fact that metastable states appear. In the case of polyatomic gases new difficulties arise due to inelastic collisions and electron affinity. The departure from the ideal gas is due to energy losses of the electrons. If the number of collisions is small these losses will be less important. That is the reason why the minimum sparking-potentials for gases are not very far apart, the difference in sparking-potential increasing with pressure and electrode distance. A. E. G.

953. *Electrical Short-Circuit Figures.* **E. Möller.** (Archiv f. Elektrot. 12. pp. 393-398, Oct. 31, 1923.)—This paper records some interesting observations of a phenomenon which does not appear to have been previously noticed. A sheet of tinfoil is placed upon a plate of glass and connected to one terminal of a source of direct-current; a pointed conductor is joined to the other terminal and the point is caused to touch the tinfoil sheet. The foil in the neighbourhood of the point is melted at the moment of contact, and the surface of the glass within the melted region is destroyed. The glass surface presents a series of furrowed lines forming a "short-circuit figure" resembling somewhat in appearance the well-known Lichtenberg figures. Photographs of the figures are given for a number of different glasses having various melting-points, both for positive and negative polarities of the tinfoil sheet. The forms taken by the figures are discussed with reference to these photographs and to an excellent series of microphotographs of details of the furrowed lines. Theories are propounded to explain the shapes of the figures and some new points of view in the study of the electrical properties of solid insulating materials are suggested. B. H.

954. *Motion of the Gas in the Electromagnetic Rotation of the Electric Discharge.* **C. E. Guye.** (Comptes Rendus, 177. pp. 1104–1106, Nov. 26, 1923. Arch. des Sciences, 5. Suppt. pp. 121–123, Nov.–Dec., 1923.)—In the case in which the collisions of electrons and ions with the molecules of the gas will in neither case produce new ions and in which the movement given them by the magnetic field is communicated entirely to the mass of the gas, the whole velocity V_0 may be represented by the equation $V_0 = \frac{N}{M - N} \cdot \frac{eH}{2\pi\sigma^2 Mm}$ in which N is the number of ions contained in unit volume of the discharge; e is the ionic charge, supposed equal to that of the electron; H the magnetic field producing the rotation; M total number of molecules, ionised or not, in the unit volume; σ and m radius and mass of molecule or positive ion. This is apparently a superior limit of the velocity V_0 for the discharge; to maintain it, necessitates the production of new ions and this absorbs a part of the energy. In the case in which the rotatory motion of the gas is due entirely to positive ions the velocity V may be put in the form $V = \frac{eH}{12\pi\sigma^2 Mm}\left(1 + \frac{3N}{M - N}\right)$ an expression which enables approximately the number of ions, N, contained in unit volume of the discharge to be accounted for. A. E. G.

955. *Spontaneous Rotation of the Electric Discharge.* **C. E. Guye.** (Comptes Rendus, 177. pp. 1282–1285, Dec. 10, 1923.)—In the preceding abstract the author has represented the velocity V of rotation of *conductibility* and the velocity V_0 of movement of the gas by the equations $V = \frac{eH}{12\pi\sigma^2 Mm}$ and $V_0 = \frac{N}{M - N} \times \frac{eH}{4\pi\sigma^2 Mm}$, the velocity observed being the sum of these two velocities. It was shown besides that the rotation may be spontaneously started even by a very weak magnetic field when the ionisation of the gas is sufficient. It is now shown that this spontaneous rotation seems to correspond with an electrodynamic phenomenon having its seat in the circuit itself, although it may be provoked by external causes such as a current of air and a magnetic field. As an appendix to this and the preceding note the method of developing the formula for V_0 is given. A. E. G.

956. *Electric Absorption and Dispersion-Spectra of Methyl and Ethyl Alcohol.* **G. Potapenko.** (Zeits. f. Physik, 20. 1. pp. 21–35, 1923.)—Wave-lengths from 30 cm. to 90 cm. were investigated. In methyl alcohol as the wave-length was shortened, the absorption-coefficient rapidly increased. In ethyl alcohol, the absorption-coefficient for shorter waves was very large, approximating to that for metallically reflecting bodies: and the dielectric constant for the shorter waves rapidly fell off, which points to anomalous dispersion. A. D.

957. *Alternating-Current Measurements in the Arc Light.* **A. Hagenbach** and **M. Wehrli.** (Zeits. f. Physik, 20. 2. pp. 96–108, 1923.)—A new method of determining high-frequency alternating-current resistances, and with it the counter e.m.f. of the arc light is described. Full details of the experimental arrangements are given. With the amalgam lamp a positive e.m.f. of 12 volts is found in the ascending part of the characteristic. The resistance measurements are found to be independent of the measured current strength in the interval between

0.0017 and 0·11 amp. The results of Duddell and also those of Hagenbach and Percy [see Abstract 739 (1923)] are confirmed. The counter e.m.f. is found to be independent of the length of the arc up to great arc-length, and from this it is concluded that in the gas column the resistances to alternating and direct-currents are equal. From this it follows that the seat of the counter e.m.f. is in the neighbourhood of, or actually in the electrodes. [See also Abstract 308 (1924).] A. E. G.

958. *Generation of Polyphase Oscillations by Means of Triodes.* **R. Mesny.** (J. de Physique et le Radium, 4. pp. 376–380, Oct., 1923.)—An arrangement of three triodes is described by means of which stable three-phase oscillations have been obtained. The arrangement is symmetrical, the filaments being connected in parallel. The three anodes are connected through inductances to a common point P and the three grids through other inductances to a common point C. The anode and grid inductances of each triode are magnetically coupled. A battery of several hundred volts is interposed between P and one side of the filaments, to which the point C is connected, either directly or through a resistance of about 12,000 ohms. Between the grids (or the anodes) of two neighbouring triodes is connected a condenser. This system spontaneously generates three-phase oscillations when the three oscillatory circuits are adjusted to have the same period and the mutual inductances have suitable values. Frequencies of the order of 10^6 have been reached without difficulty. The existence of the three-phase oscillations was demonstrated by means of a small squirrel-cage, the phase-angles being arranged to be 120°. A description is given of the method used for measuring the phases, and the precision of the measurements is discussed. [See Abstract 545 (1923).] A. W.

959. *Oscillographic Study of Some Valve Transmitters.* **A. Dufour** and **R. Mesny.** (Onde Élec. 2. pp. 620–633, Nov., and pp. 692–705, Dec., 1923.)—Describes an investigation carried out with a kathode-ray oscillograph of a few simple valve generators operating under ordinary working conditions. The chief interest lies in the numerous oscillograms reproduced. The preliminary results obtained show that the actual operation of the generators differs, in general, from the theoretical case usually treated where the variation of grid potential is sinusoidal. The research is being continued. A. W.

960. *Propagation and Reception of Wireless Waves.* **F. Kiebitz.** (Jahrb. d. drahtl. Tele. 22. pp. 196–203, Nov., 1923. Comm. from the Telegtechn. Reichsamt.)—This paper discusses generally the propagation of electric waves over the surface of the earth, reference being made to the principles of Huygens and Fresnel, curvature of the earth as affecting long-distance transmission, field strength measurements, and differences observed between winter and summer, and day and night measurements. The latter part of the paper deals briefly with the origin of disturbances which affect the reception of wireless signals. A. W.

961. *The Production of very Short Waves with Tubes having a Glowing Kathode.* **A. Scheibe.** (Ann. d. Physik, 73. 1–2. pp. 54–88, Dec., 1923.) —The following points are dealt with in this paper. The experimental arrangements for production of very short undamped waves according to the method of Barkhausen and Kurz [see Abstract 908 (1920)]. After describing the scope of the work, a description of the transmission tubes is given and also details of the methods of carrying out the measurements. In the section dealing with results obtained the points specially considered are: The grouping and form of the maxima; constance of the wave-lengths; influence of outside action upon the wave-lengths; the theoretical dependence of the wave-lengths upon the tensions and dimensions; the experimental dependence of the wave-lengths upon the emission current, the tensions, and the dimensions; the oscillation scope; the dependence of the "higher frequency" oscillations on the tensions and tube dimensions; the intensity of the waves; the longest and the shortest waves. A. E. G.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

962. *The Volta Effect.* **E. Perucca.** (N. Cimento, 25. pp. 195–211, May–June, 1923.)—Photoelectric and thermionic effects, the Volta effect *in vacuo*, and superficial tension concur, in a manner in harmony with Frankel's theory of a double layer (outer peripheral electrons and peripheral nuclei) coupled with accumulation of free electrons at the surface (which they only exceptionally cross), in supporting the anticontact theory (Lodge and Richardson) as against the old theory of simple contact, and as against the chemical theory. A. D.

963. *The Photoelectric Effect.* **E. Fermi.** (N. Cimento, 26. pp. 97–104, July–Aug.–Sept., 1923.)—In a cavity in a body at uniform temperature are electrons and the black radiation corresponding to that temperature. Striking against the sides of the cavity the electrons can be reabsorbed by the body whilst new electrons by the photoelectric effect of the black radiation will be sent from the body into the cavity. Between these two processes equilibrium must subsist. With regard to this, O. W. Richardson [Abstract 1305 (1914)] has given an integral equation having for unknown the function $\phi(\nu)$ which at least for the emissive power of the body represents the number of electrons that are emitted by the photoelectric effect when luminous energy 1 of frequency ν is absorbed. Solving the integral equation the result is got that:

$$\begin{cases} \phi(\nu) = 0 \text{ for } h\nu \leq w_0 \\ \phi(\nu) = \mathrm{H}\left(\dfrac{h}{\nu^2} - \dfrac{w_0}{\nu^3}\right) \text{ for } h\nu \geq w_0, \end{cases}$$

where h is Planck's constant, H a constant, and w_0 the energy necessary to liberate an electron from the interior of the body. This result is very interesting, for it gives a clear interpretation of the fact that the photoelectric emission does not take place till the frequency of the light exceeds a limit w_0/h. In his general theory Richardson for simplicity uses as formula for the radiation of the black body in preference to the formula of Planck: $\dfrac{8\pi}{c^3}\dfrac{h\nu^3}{e^{h\nu/\mathrm{RT}} - 1}$ another expression due to Wien, $\dfrac{8\pi}{c^3}h\nu^3 e^{-(h\nu/\mathrm{RT})}$. The formulæ of Planck and Wien coincide for high frequencies. The author gives a mathematical investigation of the modifications which Richardson's theory undergoes when Planck's formula is used, and shows first that even with the formula of Planck the result holds rigorously that $\phi(\nu)$ is zero for $h\nu < w_0$. In the second place it is shown that whilst according to

Richardson $\phi(\nu)$ for $h\nu > w_0$ keeps continuous with its first derivative, when Planck's formula is applied this last has discontinuity, with exceptions, for all the values of ν for which $h\nu = nw_0$, n being a whole number. This characteristic and unexpected result may be interpreted in a certain way perhaps from the point of view of the quantum theory; as $h\nu$ reaches the various integral multiples of w_0 new actions begin to be perceived which provoke the discontinuity mentioned. But from the experimental point of view neither theory agrees with experiment, and the experimental material collected so far upon photoelectric emission in function of the wave-length is not sufficiently extensive or certain to permit of a control of the theoretical result. From another point of view there is a parallelism between the formula of Planck and that of Wien, in the sense that the first admits as possible levels of energy $nh\nu$; the second admits only the level of energy $h\nu$. From this point of view the qualitative difference which is found on applying the one or the other is less surprising. J. J. S.

964. *The Photoelectric Conductivity of Cinnabar.* **B. Gudden** and **R. Pohl.** (Zeits. f. Physik, 18. 3–4. pp. 199–206, 1923.)—The photoelectric conductivity of cinnabar (HgS) was first described by Volmer [see Abstract 1239 (1916)]. Three publications on the spectral distribution of photo-sensitivity by Gudden and Pohl, Rose, and again by the former pair, agree in their general results, but possess certain mutual deviations which it is the first business of the present paper to explain. The peculiar influence of the electric field strength is recognised and examined [see also Abstract 449 (1921)] since the fact had been earlier disclosed that powdered crystal material exhibited outstanding maxima in high strength electric fields. For this purpose the effects of primary and secondary currents are compared, and it is found that while for the former the spectral distribution related to equal absorbed light energy only depends on the course of the optical absorption, for the latter, it is the more pronounced, the higher the potential and the denser the locality of the light absorption in the direction of the field. Discrepancies are accordingly explained by this superposition of effects. The final section of the paper discusses how far the data for cinnabar are compatible with the validity of the quantum equivalent law. While affording no proof for the latter, yet the measurements for cinnabar in conjunction with those for the diamond and zinc blende afford considerable evidence in its favour. H. H. Ho.

965. *Dielectric and Conductive Anisotropism of Fluid Crystals.* **W. Kast.** (Ann. d. Physik, 73. 1–2. pp. 145–160, Dec., 1923.)—Fluid crystals present two groups in which the dielectric constant is respectively a maximum and a minimum in the direction of the length-axis of the molecule. The relations of the heat-conductivity differ in the two groups. A. D.

966. *Conduction of Electricity through Crystals.* **F. v. Rautenfeld.** (Ann. d. Physik, 72. 8. pp. 617–628, Nov., 1923.)—The conductivity of rock salt and Iceland spar was measured, at temperatures between 630° C. and 793° C. in the case of the first, and between 232° C. and 553° C. for the second, using an alternating current. Good contact for the platinum electrodes was obtained by dusting finely divided platinum over the ground surfaces of the crystals, and pressing the electrodes against these; the crystals were heated in an electric oven. The results were plotted on

logarithmic paper, and it was found that, in the case of rock salt they could be represented by the equation $\log K = a = bt$, where K is the conductivity, t the temperature, and a and b constants. In Iceland spar the conductivity is greatest in the plate cut perpendicular to the principal axis, smallest in that cut parallel to the same, and has an intermediate value in that obtained by cleavage (the geometrical mean between the other two). The three curves are similar and agree with the formula $dK/K = \nu' dT/T^2$, where T is the absolute temperature and ν' is a constant, presumably a thermal magnitude. Thus Iceland spar, the conductivity of which according to Szlenker is electrolytic, shows a temperature relation similar to most insulators, while rock salt, whose conductivity according to Noack is at least mainly electrolytic, shows the other temperature relation of simple salts. As regards the direction in the crystal the fact that the atoms are arranged so that similar or dissimilar atoms come one after another does not seem to make much difference; their mobility sideways may perhaps be of more importance; the mechanism of conductivity is thus not as yet explained by such directional experiments.
H. N. A.

967. *Electrical Resistance of Commercial Aluminium. Influence of Impurities and Treatment.* **L. Guillet.** (Rev. de Mét. 21. pp. 12–17, Jan., 1924.)—This is a fuller account of the paper dealt with in Abstract 630 (1924). A. A. D.

968. *On the Conductivity Changes of Phosphores by Kathode Rays.* **E. Rupp.** (Ann. d. Physik, 73. 1–2. pp. 127–144, Dec., 1923.)—Previous work on the connection between the conductivity changes of phosphores has been carried out by Lenard and his co-workers for light as active agent [see Abstract 449 (1921)] and for thermal effects by Ruff [see Abstract 1658 (1923)]. The present paper extends this work for kathode rays as the active agent. Previous work on the influence of kathode rays upon dielectrics is first discussed. The different method now described in detail differs from previous modes of measurement and depends on the use of a known electrical condenser field. By it the alkaline earth sulphide phosphores afford no conductivity changes after previous exposure to radiation, while zinc sulphide shows an increase. The rate of the conductivity change has been investigated, and curves are given for CaBiα, and CaS by means of which the escaping electrons per metallic atom have been ascertained. The dependence of the conductivity change on the metallic content next receives attention, and from the results the electronic number per metallic atom is obtained. For silver and copper the electronic numbers are found to be the same while the ratio of either to bismuth is about 1·8. The result that Cu and Ag give off the same number of electrons may be associated with the position of these elements in the same vertical column of the periodic system. Finally, possible relationships between phosphore series are indicated and discussed. H. H. Ho.

969. *Electrical Conductivity of Graphite.* **E. Ryschkewitsch.** (Zeits. Elektrochem. 29. pp. 474–478, Oct., 1923.)—The values obtained for the conductivity of graphite vary greatly among themselves; even with chemically pure artificial graphite filaments measured with the greatest care, differences of 270 % were observed by Pirani and Fehse. The temperature coefficient in some cases has been found to be positive and in others negative. This is doubtless due, in part, to the fact that the substance employed consists of crystallites, and that contact resistances between these crystallites are concerned. The author has been able to obtain some single crystals of graphite, which though small, are large enough to enable resistance measurements to be made by the potential drop method, avoiding the difficulty due to the contact resistances at the ends of the small strip measured (about 0·4 cm. long, 0·1 cm. broad, and 0·004 cm. thick, the last measurement being the natural thickness of the graphite flake obtained by special treatment in the electric furnace). The measurements are difficult on account of the smallness of the unit crystals, and only four determinations have been made; in two of these the crystals showed visible lack of uniformity, and as was to be expected, a higher specific resistance than the other two more perfect crystals. The author is of opinion that the smaller value obtained with one of the last-named crystals represents most nearly the true specific resistance of graphite; this is $0{\cdot}39 \times 10^{-4}$ ohms at 0° C.; the smallest value of Pirani and Fehse is $0{\cdot}47 \times 10^{-4}$, and of D. E. Roberts $0{\cdot}50 \times 10^{-4}$. The temperature coefficient is positive, and in the neighbourhood of 0° C. is about 0·005, or very near that of most metals 0·004; the rate of increase of the coefficient diminishes as the temperature rises, $\rho = \rho_0(1 + at - \beta t^2 \ldots)$ approximately. Graphite may then be regarded as a metallic modification of carbon, while diamond is a metalloidal modification. H. N. A.

970. *Influence of Combined Carbon on the Specific Resistance of Iron.* **F. Stäblein.** (Zeits. f. Physik, 20. 3–4. pp. 209–228, 1923.)—For the measurement of small resistances a compensation arrangement has been devised which gives more accurate results than the ordinary Thomson bridge. By its means the specific resistances of a number of steels containing from 0·05 to 1·65 per cent. of carbon and only small proportions of other impurities have been measured, each sample being first tested to above the transformation point Ac_3 and afterwards left for an hour in a salt bath at 700° and cooled in ashes. The high resistance of heated steel, compared with that of pure iron, is caused, not by the dissolved carbon, but by the iron carbide formed. The kink in the curve connecting carbon content with resistance in the neighbourhood of the eutectic carbon content is attributable quantitatively to the difference in structure above and below the eutectic point. The specific resistance of pure iron is found to be 10·0 microhms per c.c., and that of cementite about 70 microhms per c.c. The latter value is exceeded in the case of a cast specimen of cementite owing to the porosity and also owing to the presence of impurities. Indeed, direct measurement of the specific resistance of iron carbide gave the value of 95 microhms per c.c. T. H. P.

971. *Effect of the Magnetic Field in Super-Conduction.* **G. Breit.** (K. Akad. Amsterdam, Proc. 26. 7–8. pp. 529–541, 1923.)—It is known that superconductivity is dependent not only on temperature but also on the magnetic field and the current-density, and it is probable that of these the first two are the only essential factors. The problem of the manner in which an applied magnetic field destroys superconductivity is examined mathematically for different conditions. In case 1, the material is initially a superconductor and the field is suddenly increased beyond the critical value. An equation is found for the rate of penetration of the non-superconducting state into the solid. In case 2, the penetration of superconductivity into a non-superconductor by withdrawal of the magnetic field is discussed, and case 3 deals with the reversal of the field. It is estimated that the thickness of the superconducting layers, produced by the suppression of a strong magnetic field, is of molecular dimensions during a perceptible interval of time. [See also Abstracts 772 (1911), 1121 (1914), 1085 (1915), 155 (1917), and 637 (1922).] G. E. A.

972. *Temperature Variation of the Electrical Resistance of Copper and Iron Fused with Mica.* **K. R. Ramanathan.** (Indian Assoc. for Cultivation of Sci., Proc. 8. 2. pp. 117–121, 1923.)—Williams and McLennan [Abstract 1648 (1920)] have shown that the electrical resistance of fused mixtures of iron and mica or copper and mica diminishes very greatly with rise of temperature. The present paper shows that the experimental results of Williams and McLennan may be expressed by the equations $R = PT^{-1}e^{Q/T}$ or $R = P_1T^{-\frac{1}{2}}e^{Q_1/T}$ where T is the absolute temperature and P, P_1, Q and Q_1 are constants. It is then shown that equations of this type are to be expected on the basis of the electronic theory of metallic conduction. A. A. D.

973. *Theory of the Reinforcement and Bond Number.* **H. Hermann.** (Phys. Zeits. 24. pp. 493–495, Dec. 1–15, 1923.)—The reinforcement number for the Volta condenser electroscope is the ratio of the observed potential to that of the e.m.f. source. In this paper the current theory of the process due to Ruoss (Zeits. phys. Chem. Unterr. 22. 345–353, 1909) is criticised, substantially confirmed, and in its essentials shown to be capable of fuller generalisation. Section 1 considers the absolute reinforcement number; section 2 deals with the practical number and the Kolbe bond number; and section 3 examines the general reinforcement number in the sense employed by Ruoss. The paper is entirely mathematical. H. H. Ho.

974. *The Initial Deflection given by the Electrometers of Braun and Haga.* **H. Hermann.** (Zeits. Instrumentenk. 43. pp. 274–278, Sept., 1923.)—The moderate damping of electrometers with rigid needles, which oscillate about horizontal axes, renders the determination of the static position of the needle during alterations in charge while oscillating often necessary. Mica damping has not yet been adopted, and damping by rhythmic capacity change is not always practicable. The needle oscillations are not symmetrical, and so a formula has been obtained for the static position of the Braun electrometer, *viz.* $\phi = 0{\cdot}4\,w + 0{\cdot}6\,v$, where w and v are the readings of the initial and turning positions. Since this previous work, however, is based entirely on small deflections, which are not accurately measurable with the Braun electrometer, although suitable for the Haga instrument, a formula is now derived for the readings of the Braun instrument. The result obtained is too complex for quotation, and the original should be consulted for the various degrees of approximation derived. H. H. Ho.

975. *Use of the Electrometer in High-Frequency Measurements.* **V. Ylöstalo.** (Annales des Postes, Télé. 13. pp. 37–47, Jan., 1924.)—Although Bjerknes has successfully made use of the electrometer in his researches on the damping of high-frequency oscillations, the instrument has gradually fallen into disuse in measurements of quantities at radio-frequencies and has been replaced by thermal instruments. In circuits with low damping and of small power the use of a thermal ammeter has considerable practical defects. The author contends that in such cases the electrometer is well adapted for radio-frequency measurements, provided that an instrument of simple construction, high sensitivity, low self-capacity, and small energy consumption can be constructed.

A sensitive electrometer, used idiostatically, is described and is shown to possess all the desired features just mentioned. Details of the design, sensitivity, adjustment, and possible sources of error are given; the scale of the instrument follows exactly a quadratic law. Various uses of the electrometer in radio-frequency measurements are described, *e.g.* determination of the resonance curve, the decrement, and the effective resistance of an oscillatory circuit, and the measurement of self-inductance. The results are compared with measurements made by thermal ammeters; the errors introduced by the high resistance of these instruments relative to the resistance under test and by their large power consumption are clearly demonstrated. B. H.

976. *The Dynamometer Wattmeter.* **B. Hague.** (Electrician, 92. pp. 96–97, Jan. 25, 1924.)—The two standard methods of connecting a wattmeter to measure the power passing from the a.c. supply to a reactive load are shown, together with the appropriate vector diagrams in Figs. 1 and 2. The point which the author demonstrates is that the order in which the two corrections, (1) for the instrument losses and (2) for the potential coil reactance, are to be applied to the instrument reading is different in the two cases. With the potential coil of the wattmeter connected on the alternator side of the current coil, the Power in load = K_{AC} (Wattmeter reading) − Power loss in current coil; where $K_{AC} = \cos\phi_{AC}/[\cos\phi_p \cos(\phi_{AC} - \phi_p)]$ and the phase-angles concerned are as shown in Fig. 1. With the potential circuit connected on the load side of the current coil, the power in load = K_{BC} (Wattmeter reading − Power loss in potential coil); where $K_{BC} = \cos\phi_{BC}/[\cos\phi_p \cos(\phi_{BC} - \phi_p)]$; the phase-angles involved being now as shown in Fig. 2. It will be seen that in the first case the correction for the reactance of the potential circuit is applicable to the wattmeter reading before the correction for the instrument loss, whereas in the second case the reactance correction is applied after the wattmeter reading has been reduced by the amount of the instrument loss. Although the correcting factors are of the same form in each case, the phase-angle of the load alone is involved in the second case, whereas in the first case the angle is the total phase displacement over the load and the current coil in series. In general the difference between ϕ_{AC} and ϕ_{BC} is slight, but the difference may be important when the equivalent resistance and reactance of the load are also small. R. E. N.

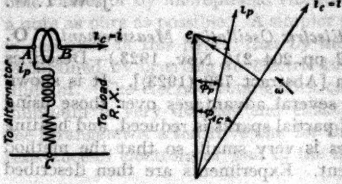

FIG. 1.

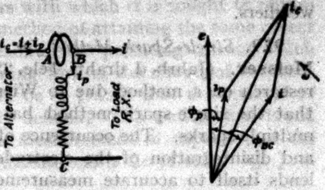

FIG. 2.

977. *Measurement of Peak Voltages.* **R. D. Mershon.** (El. World, 83. pp. 189–190, Jan. 26, 1924.)—The paper describes an accurate zero method of measuring peak voltages which utilises only standard apparatus, the whole arrangement being easily portable. A tungar rectifier is used to rectify the alternating voltage (or a known fraction of it) of which the peak value is to be found, this rectified voltage being balanced against a steady voltage produced by a d.c. potentiometer. A telephone is used to detect balance. So long as the direct voltage exceeds the peak value no sound will be heard in the telephone; the characteristic alternating-current tone will appear when the direct voltage is just less than the peak. The potentiometer is therefore adjusted until silence is just attained. Two sets of readings are taken for different fractions of the alternating voltage and a method of differences is employed to eliminate a zero error due to direct influence of the rectifier itself. The conditions for sensitive working are discussed, and two schemes of connection are shown. The method is also applicable to the measurement of peaks at frequencies so high that they do not of themselves produce an audible note. Transient voltages that are reproducible at will can also be determined by the apparatus. B. H.

978. *Theory of Absolute Electrodynamometers.* **H. Hermann.** (Zeits. Instrumentenk. 43. pp. 351–357, Dec., 1923.)—A mathematical treatment of the theory of various types of electrodynamometers and current weighers. J. W. T. W.

979. *Single-Spark Method for Electric Oscillation Measurements.* **O. Meisser.** (Jahrb. d. drahtl. Tele. 22. pp. 204–216, Nov., 1923.)—Describes research on a method due to Wien [Abstract 789 (1923)]. It is shown that the single-spark method has several advantages over those using multiple sparks. The occurrence of partial sparks is reduced, and heating and disintegration of the electrodes is very small, so that the method lends itself to accurate measurement. Experiments are then described in which circuits, electromagnetically coupled, are shock excited by a single-spark primary circuit whose decrement is much increased by means of a fluid resistance. The method was employed to investigate the critical coupling between two circuits. The results are tabulated and show the critical coupling for the circuits used to be about 3 %. A. W.

980. *Decrement Determinations, especially for Highly Damped Circuits.* **O. Meisser.** (Jahrb. d. drahtl. Tele. 22. pp. 217–229, Nov., 1923.)—A discussion is first given of the applicability of Bjerknes' formulæ and methods to the single-spark shock excitation method previously described [see preceding abstract]. It is shown that Bjerknes' formula is valid for very large decrements, and that his method of evaluation can be applied quite generally. Experiments with circuits having small decrements have results in excellent agreement with theory, and for circuits with strong damping the results were not more than a few per cent. out. A. W.

981. *Application of Oscillating-Valve Circuits to Precise Measurement of Physical Quantities.* **J. E. P. Wagstaff.** (Phil. Mag. 47. pp. 66–84, Jan., 1924.)—Whiddington and others have indicated the utility of the oscillating-valve circuit in making certain physical measurements of quantities which can be reduced to some change of electrostatic capacity.

The author in this paper gives an investigation of some of the applications of the method. Two valve-maintained oscillatory circuits generating oscillations of the order of a million cycles per second are arranged to produce a beat note of audible frequency in a loud-speaking telephone. The condenser to be measured is joined in parallel with the condenser in one of the oscillatory circuits and its capacity is determined from the observed change in the beats. Full details of calibration of the audible notes and of the high-frequency oscillations are given and the applicability of the usual Thomson formula for the dependence of frequency on capacity is critically discussed.

Using this method the following problems are investigated : (i) Determination of the dielectric ratio of air and its variation with pressure ; (ii) measurement of magnetic susceptibilities, using a small condenser with one of its plates attached to one end of a torsion balance beam to the other end of which the specimen is attached in such a way as to hang in a known magnetic field ; (iii) measurement of the strength of a magnetic field ; (iv) tests on the effect of electrostatic charge on the surface tension of mercury. Full experimental details are described. B. H.

982. *Measurements with the Electric Tuning Fork.* **S. Timpanaro.** (N. Cimento, 25. pp. 287-289, May-June, 1923.)—Measurements with the telephone bridge are usually made with the employment of alternating currents furnished by special induction coils or by generators with thermionic valves or by microphonic vibrators with which it is sought to obtain a note as pure as possible. A simpler method of attaining the same object is described in this paper, that by means of the pulsating current which is obtained by inserting an electric tuning fork in the circuit of an accumulator. The electric tuning fork can be so placed that the interval of minimum is very distinct and exactly defined. The author has found the arrangement a sensitive one for the measurement of capacity, of the resistance of electrolytes, and of the internal resistance of cells. J. J. S.

ALTERNATING CURRENTS AND MAGNETISM.

983. *Rotating Currents.* **E. Persico.** (N. Cimento, 26. pp. 41-44, July-Aug.-Sept., 1923.)—Cross alternating currents in phase-quadrature would produce a resultant with rotating vector which would produce no magnetic field ; but if we take into account positive and negative ions of different mass as the carriers of the current, there ought to be a residual magnetic field produced. This is, however, of the order $\phi = 10^{-21}$ e.-m. units for platinum. A. D.

984. *Alternating-Current Resistance and Inductance of Single-Layer Coils.* **C. N. Hickman.** (Bureau of Standards, Sci. Papers, No. 472. pp. 73-104, 1923.)—New formulæ are developed for the resistance and inductance of parallel "go and return" circuits consisting of the same number, size, and spacing of wires as in the coil. The conditions are examined under which these formulæ are applicable to the coils. The methods are an extension of that of Curtis [Abstract 306 (1921)]. Experimental results are given at frequencies of 1000 to 3000 on large coils wound with bare copper wire 5·19 mm. diam. The measured values agree very closely with those calculated by the new formulæ, but differ greatly from those calculated by the formulæ of Sommerfeld and Butterworth. G. W. O. H.

985. *Polar Oscillograms.* **A. G. Beliavsky.** (Electrician, 92. p. 38, Jan. 11, 1924.)—Polar oscillograms are especially useful in determining alternating-current curve deformations. The voltage curve may be considered practically as a sine curve if its instantaneous voltage does not differ from the instantaneous voltage of the first harmonic wave by more than 5 per cent. of the maximum ordinate of the first harmonic. The construction of this curve involves tiresome calculations, whereas in the polar coordinate system the first harmonic produces an exact curve whose construction presents no great difficulties. The examination of the polar oscillograms for steady and unsteady states and particularly for damped oscillations are of great practical interest. By photographic means a polar oscillogram can be obtained from an ordinary oscillograph, depending on the fact that the sensitive film fastened on to the disc is revolving and on it is oscillating in the radius direction the light-ray coming from the looking-glass of the oscillograph. If the disc rotation is synchronous with the current passing through the oscillographic loop a polar oscillogram is obtained. T. C. H.

986. *Oscillographic Study of Current and Voltage in a Permeameter Circuit.* **W. B. Kouwenhoven** and **T. L. Berry.** (Am. I.E.E., J. 42. pp. 1305–1308, Dec., 1923.)—A permeameter of the **U**-shaped yoke type was employed, and the magnetising current, and the e.m.f. induced in a search coil wound over the magnetising coil, were measured by an oscillograph. Using a carbon break magnetic blow-out circuit-breaker, first with open, then with closed magnetic circuit, the times to reduce the current (7·5 amps.) to zero were 1·25 and 1·68 seconds; oscillogram curves are given. With a 20-ampere snap switch immersed in oil, the times in the two cases were reduced to 0·23 and 0·24 second; a current of 0·66 amp. was interrupted in 0·02 second. The lag of the flux behind the magnetising current was found to be caused by eddy currents in brass rings at the ends of the magnetising solenoid; on removing the rings, the lag almost completely disappeared. Two new permeameters were then constructed in which the use of a laminated core was found materially to reduce the time of reversal of the current. G. E. A.

987. *Diamagnetism of the Gases Helium and Argon.* **G. Joos.** (Zeits. f. Physik, 19. 5–6. pp. 347–350, 1923.)—Pauli has shown [see Abstract 728 (1921)] that values for the principal electrical moments of inertia derived from the experimental data for the diamagnetism of helium and argon are ten times greater than those to be expected from theory. The data relating to measurements of the susceptibility of salt solutions are employed to calculate the atomic susceptibility of ions of the above gases. The values thus found are in agreement with those to be expected according to Bohr's theory; direct measurements do not confirm these results. G. E. A.

988. *A New Electromagnet.* **H. Boas** and **T. Pederzani.** (Zeits. f. Physik, 19. 5–6. pp. 351–374, 1923.)—After reference to the electromagnets of Ruhmkorff, Ewing, du Bois, and Weiss, an electromagnet is described in which the Ruhmkorff form is retained. Air cooling is adopted, a motor for this purpose being housed within the yoke. The electromagnet windings consist of a series of flat coils separated by spaces to facilitate cooling. Copper strip is used for the conductor and is wound into eight cotton-covered coils, each of eighty turns, on each limb. The coils are boxed in, and the cooling is such that a current of 25 amperes at 132 volts can be kept on indefinitely. Measurements with the electromagnet are detailed with graphs which give the output with flat and conical pole-pieces, varying pole distance and varying current. The weight of the magnet is 219 kg., its resistance with a rise of temperature of 55° is 5·3 ohms, and the power required is 3·4 kw. With a pole gap of 1 mm. between faces 10 mm. in diameter, the field obtained is 48,000 c.g.s. With ferro-cobalt pole-pieces a higher efficiency could be attained. G. E. A.

989. *Susceptibility of Paramagnetic Double Sulphates at Low Temperatures.* **L. C. Jackson** and **H. K. Onnes.** (Roy. Soc., Proc. 104. pp. 671–676, Dec., 1923. Comm. No. 168B from the Phys. Lab., Leiden.)—An extension of previous work [see Abstracts 1988 and 1989 (1923)] to the cobalt potassium, cobalt rubidium, and manganese ammonium sulphates. From measurements on these substances over a range of absolute temperature 291° to 15°, it is found that the cobalt compounds follow the law: $\chi'_m(T + \Delta) =$ constant down to about 70° abs., where χ'_m is the molecular susceptibility corrected for the diamagnetism of the anion. The substances have approximately equal Δs, but at temperatures lower than 70° the value of χ'_m is greater than that calculated from the above law. The manganese ammonium salt obeys the simple Curie law; $\chi T =$ constant over the whole range of temperature used. The magneton numbers found for the above substances were 25·32, 26·38, and 29·21 respectively. G. E. A.

990. *The Photomagnetic Effect.* **N. v. Raschevsky.** (Zeits. f. Physik, 20. 3–4. pp. 191–195, 1923.)—J. Dorfmann has recently shown that the alteration of the space quantum number of a molecule is accompanied by an emission or absorption of light, and that therefore an absorption of light can result from magnetisation [Abstract 2513 (1923)]. The author in 1918, in a paper published in Russian, dealt with the possibility of such an effect from the classical point of view, and recapitulates the mathematical treatment employed in the present paper. The amount of magnetisation to be expected, according to these calculations, in cæsium vapour, is very minute indeed, when circularly polarised light is passed through it, and this agrees with an experiment by Righi, who could find no effect with NO_2, although the magnetometer he employed was a sensitive one. Using the quantum theory not only the space quantum number, but also the azimuthal quantum number concerned with the absorption of a circular polarised light wave, must alter the magnetic moment of a molecule. H. N. A.

991. *Magnetic Ageing of Iron and Steel.* **T. E. Green.** (World Power, 1. pp. 41–43, Jan., 1924.)—In transformers the effect of ageing in soft iron is seen in the increased hysteresis losses which take place in the course of time. Losses due to this cause were almost entirely eliminated with the invention of silicon steel, but the physical and chemical changes involved are still only imperfectly understood. A table of tests by Clinker shows that the percentage loss is greater in the annealed than in the unannealed specimen. With permanent magnets the effect of maturing is considered, and various facts are brought forward, *e.g.* the permanence of certain magnets was greater in the larger of these magnets; also steel quenched in water is harder than steel quenched in oil, but the second of these has greater magnetic permanence. It is concluded that much remains to be done in the field of magnetic ageing. G. E. A.

992. *Magnetic Hysteresis at High Frequencies.* **W. Kaufmann.** (Phys. Zeits. 24. p. 504, Dec. 1–15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—The question of a change in the form of hysteresis curves due to a time-lag in magnetisation is one on which experimenters disagree. Two hysteresis curves are given, each drawn through points obtained by two methods, namely the statical and one using a frequency of 500, for an iron wire 0·15 mm. in diameter. The eddy-current effect is estimated at less than 2 per cent., and the time-lag in magnetisation is regarded as quite negligible. G. E. A.

993. *Magnetic Hysteresis.* **Brylinski.** (Ann. de Physique, 20. pp. 241–247, Sept.–Oct., 1923.)—A mathematical investigation of the expression for the induction in terms of the field for a ferro-magnetic substance using a Fourier series of the form

$$\mathrm{B}\sin(\omega t-\phi)+\mathrm{B}_3\sin(3\omega t-\phi_3)+\ldots+\mathrm{B}_{2n+1}\sin[(2n+1)\omega t-\phi_{2n+1}]$$

the field being a harmonic function of t and the induction consequently expressed as a function of t.

Neglecting higher terms, $\mathrm{B}^2-2\mu\mathrm{BH}\cos\phi+\mu^2\mathrm{H}^2=\mu^2\mathrm{H}m^2\sin^2\phi$, an ellipse approximating in shape to the hysteresis loop. Since energy/unit volume $=\frac{1}{4}\mu\mathrm{H}m^2\sin\phi$, and using Steinmetz formula for the loss of energy, $\sin\phi=4\eta\mu^{n-1}\mathrm{H}m^{n-2}$, where η = Steinmetz coefficient, determining ϕ. The method is applied to the problems of a cylindrical conductor of given radius. W. V. M.

994. *Magnetic Properties of Silicon Steel in a Large Transformer.* **G. H. Cole.** (Elect. J. 21. pp. 17–24, Jan., 1924.)—A detailed study is given of the magnetic properties of 4 % silicon steel in a 4166 kv.a., single-phase, 60-cycle transformer, the core plates being 0·36 mm. thick. Circular oscillograms were taken at various inductions and at 25 and 60 frequency. Hysteresis loops were also taken with direct-current, at various maximum inductions from 1000 to 19,000 gauss, by means of a volt-second meter apparatus [see Abstract 1101B (1915)]. The magnetising current corresponding to these loops was analysed into its component harmonics, and the current waves actually obtained at 25 and 60 frequency also analysed, and the core loss deduced from the results of the analysis, in addition to being measured by means of a wattmeter. Core-loss loops, deduced from the oscillograms, are given in the paper, as well as graphs showing the manner in which the magnitudes of the various harmonics in the exciting current are dependent upon the value of the maximum induction density. It is not possible to abstract in detail the great wealth of information contained in the paper, but the following points may be mentioned. The eddy-current losses in the transformer were a larger percentage of the total than in an Epstein sample, owing to the greater mechanical pressure. At 60 cycles, the eddy-current loss was 24 per cent., and at 25 cycles, 11 per cent. of the total loss; these percentages varied little with the induction, and in no consistent way. Throughout the lower range of the induction—up to

9000 gauss—the Steinmetz index for direct-current hysteresis was 1·64; for alternating current hysteresis 1·68; and for the total core loss it was 1·75. For inductions above 9000, these figures no longer hold. At about B = 18,000 the slope of the direct-current hysteresis loss curve was found to be increasing as the fifth power of the induction.

A slight variation from a sine wave in the impressed voltage had a marked effect on the current wave shape. For B = 12,000 the amplitudes of the fundamental, third, fifth, seventh, and ninth harmonics of the current were respectively 90, 41·5, 12, 2·5, and 1·5 per cent. approximately of the amplitude of the equivalent sine wave. A. E. C.

995. *Theory of the Magneton.* **A. Sommerfeld.** (Zeits. f. Physik, 19. 4. pp. 221–229, 1923.)—Pauli first brought forward the view that for the calculation of paramagnetic susceptibility the spatial quantelation should be considered. The magneton numbers of Weiss can be reduced to small whole multiples of the quantum theory unit (Bohr's magneton). Pauli's calculation is based on the spatial quantelation of the hydrogen atom; that is, the normal Zeeman effect. The author has already noticed that the formula of Pauli needs correction if it is to be used for non-hydrogen atoms, *i.e.* for atom states which behave anomalously in the Zeeman effect. In this paper he considers the correction and its influence on the magneton numbers concerned. Then the beautiful regularity which henceforth is exhibited in the distribution of the magneton numbers over the region of the periodic system which comes into consideration is noticed. J. J. S.

996. *Magnetic Circuit of Permanent Magnets.* **G. H. Perrin.** (Rev. Gén. d'Él. 14. pp. 963–965, Dec. 15, 1923.)—From a consideration of the magnetic circuit it is shown that the volume of a permanent magnet should vary in the inverse direction with $(BH)_{max.}$ and that its length should diminish as μ diminishes. The value of a steel for a magnet is indicated by the product BrHc for the steel; high permanence requires a low value of Br/Hc. [See also Abstract 367B (1921).] G. E. A.

997. *Magnetic Researches. Part XXII. Determination of the Magnetisation at Very Low Temperatures, and Susceptibility of Gadolinium Sulphate in the Region of Temperatures Obtainable with Liquid Hydrogen.* **H. R. Woltjer.** (K. Akad. Amsterdam, Proc. 26. 7–8. pp. 613–625, 1923. Comm. No. 167B from the Phys. Lab., Leiden.)—The value of extending the investigation of the magnetisation of paramagnetic substances to the temperatures obtainable by means of liquid helium was confirmed by the work of Onnes on the magnetisation of gadolinium sulphate [Abstract 119 (1915)]. The methods used for measuring the magnetisation (see following abstract) are described and the necessary corrections considered in detail, special attention being paid to the topographic calibration of the electromagnet, which was carried out partly by investigating gadolinium sulphate in liquid hydrogen. The value of the magnetic susceptibility of this salt is $1 \times 0566 \times 10^{-3}$ at 20·31° K. and $1·4663 \times 10^{-3}$ at 14·68° K., the corresponding values for the Curie constant being $2·146 \times 10^{-2}$ and $2·152 \times 10^{-2}$. T. H. P.

998. *Further Experiments with Liquid Helium. Magnetic Researches. Part XXIII. Magnetisation of Gadolinium Sulphate at Temperatures*

Obtainable with Liquid Helium. **H. R. Woltjer** and **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 26. 7–8. pp. 626–634, 1923. Comm. No. 167c from the Phys. Lab., Leiden.)—From the results of measurements of the specific magnetisation of powdered hydrated gadolinium sulphate [see Abstract 119 (1915)] at temperatures ranging from 1·31° K. to 4·20° K., it appears that Langevin's formula holds, although the fundamental assumptions of Langevin's theory do not apply. For the parameter a of this theory the value 7 is almost reached. The highest magnetisations obtained are about 84 per cent. of that corresponding with perfect parallelism of all elementary magnets; this result is independent of the uncertainties in the temperature and in the value of the demagnetising field. Hence, Ehrenfest's theory is not applicable in this case without further extension, since this theory, which is based on quanta assumptions and, unlike Langevin's theory, is valid directly for crystal powders, gives for the saturation magnetisation only 50 per cent. of the above value. T. H. P.

999. *Status of Magnetic Surveys,* 1922. (Internat. Geodet. and Geophys. Union, Bull. No. 3. pp. 31–56, Oct., 1923.)

1000. *Comparisons of Magnetic Instruments and Methods of Absolute Magnetic Measurements.* (Internat. Geodet. and Geophys. Union, Bull. No. 3. pp. 75–99, Oct., 1923.)—Report of Chairman of Committee.

1001. *Magnetic Declination, Kew.* **C. Chree.** (Meteorolog. Office, Geophys. Mem. No. 22, pp. 21–47, 1923.)—The absolute daily range of magnetic declination (*i.e.* the excess of the absolute maximum over the absolute minimum of the day) is found for all available days of the 42 years 1858–1873 and 1875–1900. The times of the occurrence of the daily maximum and minimum are also determined. The agreement with sunspot frequency for the later periods is very close, and discrepancies in the earlier period remain unaccounted for. Annual and diurnal variations and distributions are also considered. There appears to be a considerable consensus of evidence in favour of a progressive retardation of the day maximum. W. A. R.

1002. *Results from Magnetic East–West Paths around the Earth.* **W. J. Peters.** (Terrest. Magn. 28. pp. 83–88, Sept., 1923.)—Various methods of constructing paths round the earth, which are everywhere perpendicular to the horizontal component of the earth's magnetic field, are reviewed. A graphical method, employing isogonic charts, is decided upon as most practicable, and the results are given of the construction of eleven such paths, beginning at different points on the meridian of Greenwich and passing completely round the earth back to this meridian. Certain British Admiralty charts for the epoch 1922 are used. The paths do not arrive back on the Greenwich meridian quite at the starting-point, and a measure of the lack of closure of each is given, and the quantity, arc tan (p/s), is tabulated, where p is the perpendicular distance between the initial and final portions of the path and s is the length of the path. This gives the average angle east or west of magnetic north that the direction of the horizontal component of the earth's magnetic field must have been deflected from the direction a magnetic potential system would give it, in order to produce the lack of closure. For paths in the northern hemisphere the average value of this average angle is 3′ east, while for the southern hemisphere it is 9′ west, quantities in fair agreement with certain conclusions of Bauer as the result of the indicated existence of a non-potential system which contributes about 3 per cent. to the magnetic force observed at the earth's surface. M. A. G.

1003. *Simple Measure of the Earth's Daily Magnetic Activity.* **L. A. Bauer.** (Internat. Geodet. and Geophys. Union, Bull. No. 3. pp. 103–106, Oct., 1923.) *Criterion of Magnetic Disturbance.* **C. Chree.** (Internat. Geodet. and Geophys. Union, Bull. No. 3. pp. 107–114, Oct., 1923.)—The need for a more precise measure of the degree of magnetic disturbance of a particular day than that furnished by the existing scheme of international "character" figures, has led to discussion as to what would be a suitable measure to adopt. Since Bidlingmaier suggested his measure of magnetic "activity" as the mean value of $(\Delta x^2 + \Delta y^2 + \Delta z^2)/8\pi$ for the day at the station concerned, where Δx, etc., represent departures from "normal" of the three rectangular components of magnetic force, several other investigators, including the present authors, have proposed measures. The present papers embody the views of their respective authors on the subject, both from the theoretical and practical standpoint, as presented at a discussion at the Rome meeting last year of the Section of Terrestrial Magnetism and Atmospheric Electricity of the International Union of Geodesy and Geophysics. In Bauer's paper will be found a convenient summary of the various measures proposed, with a comparison using actual data. M. A. G.

RADIOGRAPHY AND ELECTRO-PHYSIOLOGY.

1004. *On Certain Differences in the Measurements upon X-Ray Protective Materials.* **H. Franke.** (Phys. Zeits. 24. pp. 474–475, Nov. 1–15, 1923. Paper read before the Deut. Physikertag., Bonn, Sept., 1923.)—During recent years the usual 4-mm. lead protection has been replaced by walls in which heavy spar ($BaSO_4$) forms the chief component. Whilst the manufacturing firm claims a lead equivalent of a 6-cm. thick wall as 4–6 mm. lead, other claims have been made of an equivalence of 11 mm. lead. This is explained by the manufacturers using a 200-kv. therapy installation for test purposes, whilst the other observers have used installations of lower voltage. Tests carried out upon plates of varying thickness showed a 15 % lead equivalent for a thickness of 7·5 mm. and a lead equivalent of 7 % for thicknesses of 60 mm. As a practical result, on the introduction of any new protective material, the conditions under which it is to be operated must be specified, as errors may arise owing to selective absorption. **Errata** (*Ibid.* 25. p. 24, Jan. 1, 1924). B. J. L.

1005. *The Application of Electricity to Medicine and Surgery.* **G. Panbianco.** (Elettrotecnica, 10. pp. 766–770, Nov. 15, 1923.)—In this paper, after a very brief account of the ways in which electricity can be employed by the medical profession, more detailed descriptions, with illustrations, are given of X-ray apparatus and, especially that in which a Coolidge tube is used. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1006. *Second Report of the Committee on Contact Catalysis.* **W. D. Bancroft.** (J. Phys. Chem. 27. pp. 801–941, Dec., 1923.)

1007. *Action of X-Rays upon Platinum Catalysis.* **R. Schwarz and M. Klingenfuss.** (Zeits. Elektrochem. 29. pp. 470–474, Oct., 1923.)—Experiments were carried out to determine the cause of increased output in the contact sulphuric acid process (in which finely divided platinum acts as a catalyser) when the catalyser is subjected to X-radiation. The hypothesis is made that the action of the radiation is to split up water, in the form of steam, into its constituents and the oxygen is obtained in a chemically active (nascent) form which forms a peroxide of platinum, the latter metal acting as an oxygen carrier. Various experiments are described in detail with tables of data obtained, and the part played by the water is considered. As a result it is concluded that X-rays give rise to a β-radiation which has a photolytic action upon water, producing active oxygen, which then acts as already stated. Fatigue of the platinum during the process is due to its smaller oxygen content when in this state. An alternative explanation by Ellinger, in which the oxygen process is intensified by negative electrons given out by the metal under the action of X-rays, is stated to be erroneous, as in this explanation water plays no part. B. J. L.

1008. *Nature of the So-called Adsorptive Power of Finely Divided Carbon.* I. *Binding of Water by Animal Carbon.* **J. R. Katz.** (K. Akad. Amsterdam, Proc. 26. 7–8. pp. 548–560, 1923.)—The validity of Freundlich's formula representing the fixation of substances by carbon [Abstract 1234 (1907)] is not a sufficient proof that the phenomenon is one of surface adsorption, and more information is obtainable from simultaneous measurement of the fixation isotherm and of the heat of sorption as a function of the quantity of fixed substance.

The results of experiments made on the fixation of water by the purest animal carbon obtainable show that the isotherm comprises an almost horizontal middle part, similar to that found with the isotherm of freshly made silicic acid; the curve showing the heat of fixation exhibits a corresponding horizontal portion. On the assumption that the form of these curves is due to the existence in the carbon of a system of microcapillaries, the radius of such capillaries is calculated to be $1 \cdot 2 - 2 \cdot 6\ \mu\mu$. It is noteworthy that this value agrees closely with that found in the case of silicic acid. The author is, however, doubtful whether the above explanation of the phenomenon is the true one, and it is suggested that a more probable explanation lies in the difficult moistening of the carbon by the water. A striking point is the pronounced hysteresis of the isotherm. T. H. P.

1009. *Are the Natural Groupings of the Elements and the Spectral Lines of Hydrogen Related?* **F. H. Loring.** (Chem. News, 127. pp. 257–259, Oct. 26; 273–275, Nov. 2; 290–291, Nov. 9; 337–339, Nov. 30; 355–358, Dec. 7; 369–372, Dec. 14; 386–388, Dec. 21, 1923; 128. pp. 5–8, Jan. 4; 17–18, Jan. 11; 49–54, Jan. 25, and p. 81, Feb. 8, 1924.)—The author plots the wave-lengths of the lines H_α, H_β, H_γ, H_δ, and H_ϵ of the Balmer series of hydrogen against the numbers 7, 9, 13, 21, and 24, which he obtained in connection with his five natural groups and groupings of the elements (Chem. News, p. 225, 1923), and finds that the relation of the two sets of quantities is a linear one; he considers that this suggests that the "place principle" of the main hydrogen orbits is fundamentally the same as the places in the periodic table, as represented by his natural groups and groupings, and proceeds to discover similar numerical relations between the distances of the planets from the sun, and of the satellites in the solar system from their planets. On these grounds he proposes a modification of the Bohr theory. H. N. A.

1010. *The Present Position of the Periodic Law.* **W. R. Cooper.** (World Power, 1. pp. 18–24, Jan., 1924.) A review of the subject.

1011. *Physical Chemistry of the Vehicle and of the Emulsion.* **T. S. Price.** (Faraday Soc., Trans. 19. pp. 256–260, Nov., 1923. Comm. No. 31. from British Photo. Research Assn. Lab.)—The particular properties gelatin possesses which make it especially suitable as an emulsion medium is the subject of this paper. In discussing these properties gelatin is contrasted with collodion, the other medium which is largely used for certain types of photographic emulsions. It is, however, concluded that we are still in the dark as to what makes gelatin so valuable as a sensitising material. A. E. G.

1012. *Structure of the Photographic Emulsion.* **E. P. Wightman, A. P. H. Trivelli** and **S. E. Sheppard.** (Eastman Kodak Co. Research Lab., Comm. No. 180. Faraday Soc., Trans. 19. pp. 270–279, Nov., 1923.)—The object of this communication is to help to build up a general theory of emulsion formation, in the light of present advances in colloid chemistry, in crystallography, and atomic structure. The study of the structure of the emulsion is here divided into two principal problems: (1) The habit (shape) of the individual crystal and the distribution of shapes. (2) The size (dispersity) of the primary grains, and the distribution of their sizes. Subsidiary, although important, problems are: (3) The "clumping" of primary grains and secondary aggregations. (4) The adsorption of substances to the grains. The last of these is here considered as a factor modifying crystal habit rather than a feature of the complete structure. A. E. G.

1013. *Sensitivity of a Silver Bromide Emulsion; Action of Chromic Acid.* **W. Clark.** (Faraday Soc., Trans. 19. pp. 309–313, Nov., 1923. Comm. No. 23. from British Phot. Research Assn. Lab.)—From the experimental results given it follows that the product of the action of light (and fogging agents) on the plate is much more readily attacked by chromic acid (and acid-bromide-dye mixtures) than is the sensitivity-giving material itself, although this latter is slowly attacked. Increase in the preliminary exposure, past a certain minimum value, for a given time of immersion in chromic acid, does not bring about a corresponding decrease in sensitivity. The reduction in speed produced by chromic acid treatment is not due merely to adsorption of the densitiser by the silver halide. The action of the chromic acid is to decrease the speed of the plate, to increase the gamma and lower the range and also to diminish the fog. As regards the actual mechanism of reduction of sensitivity by chromic acid, it must act either by absolute removal of the sensitivity-promoting substance, by its conversion into a photo-insensitive material, or else after the manner of a " catalyst poison." It is extremely probable that the removal of the latent image is by solution of its substance by the chromic acid; but if the purely desensitising action is to convert the " vital substance " itself *in situ* into an insensitive compound, it should be possible by suitable chemical means to reconvert it to its original form with a consequent restoration of sensitivity. A. E. G.

1014. *Under-Exposure Period of the Characteristic Curve.* **R. Luther.** (Faraday Soc., Trans. 19. pp. 340–348, Nov., 1923.)—The general conclusions drawn in this paper are the outcome of the examination of about 700 characteristic curves. It is considered that as a first approximation to the truth it may be accepted that in the under-exposure portion all characteristic curves of the same gamma are geometrically similar, so that a single constant is sufficient to express the shape of the curve in this region. Experiments show that this constant depends primarily on the emulsion, considerably less on the developer, and scarcely at all on the gamma. This constant is independent of the sensitivity itself but in general the " weakest " emulsions are also the most sensitive. It can also be stated with a fair degree of accuracy that the slope of the characteristic curve at the inertia-exposure is about one-half of γ. A few mathematical trials are made to formulate the nature of the indefinite function, f, in such a way that it should satisfy the conditions given, and correspond with the empirical form of the characteristic curve, and also, if possible, have a theoretical basis. Two functions are examined more closely in this connection, (1) a purely empirical one, and (2) one based partly on theoretical grounds. The question of proportional reduction is discussed, and a new method of intensification is described. A. E. G.

1015. *Chemical Valency of the Metals as an Energy Question.* **H. G. Grimm** and **K. F. Herzfeld.** (Zeits. f. Physik, 19. 3. pp. 141–166, 1923. Phys. Zeits. 24. pp. 486–488, Nov. 1–15, 1923.)—The positive valency of a metal, corresponding with the liberation during chemical reactions of a number of electrons equal to the valency number, is shown by decomposition of the heat of formation into elementary magnitudes not to be determined solely by the magnitude of the work of ionisation for the detached electrons; it depends, besides, on the heats of sublimation of the participants in the reaction and on two magnitudes relating to the anion, especially on the lattice energy of the product of the reaction. The positive maximum valency, that is, the valency which increases in every period with the group number of the periodic system, is determined by the fact that the " driving chemical forces " (actually the lattice energy which increases with the valency) may furnish the corresponding increasing work of detachment for the valency electrons, but is no longer able to provide the relatively greater amount of work required to withdraw an electron from a stable shell. An exception to this occurs with the cupric ion.

The sharp change in valency occurring with the elements at the beginning of principal and sub-series depends on the existence of a distinct maximum for the heat of formation of those compounds of which the kation has given up the electrons situate outside of a stable shell. The periodicity of chemical properties, that is, the recurrent repetition of similar valency relationships in the system of the elements is conditioned, not only by repetition of similar relations determined by the number and work of liberation of the electrons, but also by a corresponding similarity in the lattice energy, etc., the heats of formation of the compounds of homologous kations being of similar orders of magnitude. T. H. P.

1016. *Valence and the Electron.* **G. N. Lewis.** (Faraday Soc., Trans. 19. pp. 452–458, Nov., 1923.)—This address consists of a discussion of such controversial topics as the physicist's and chemist's views of the structure of the atom, the electron pair and its function as the chemical bond, nomenclature of the valence theory, multiple bonds, tautomerism, conjugation, and electrical polarisation in the molecule. T. H. P.

1017. *Bohr's Atom in Relation to the Problem of Covalency.* **R. H. Fowler.** (Faraday Soc., Trans. 19. pp. 459–468; Disc., 476–482, Nov., 1923.)—The author deals with some of the difficulties encountered when attempts are made to apply modern views of atomic structure to the structure of molecules and to the chemical problems of valency. Among the points considered are the physical interpretation of covalency, the possibility of the sharing of odd numbers of electrons and the bearing of such shared electrons on the question of directed valencies and of double and triple bonds, the impossibility of quadruple bonds according to the physical theory, and the distinction between covalency and electrovalency in the case of hydrogen.

The possible modification of the order of development of different shells of electrons by chemical modifications is discussed in connection with the hydrides of boron, the anion of potassium hydrogen fluoride, sulphur hexofluoride and the silicofluorides, and the coordinated compounds of cobalt. T. H. P.

1018. *Nature of the Non-Polar Link.* **N. V. Sidgwick.** (Faraday Soc., Trans. 19. pp. 469–475; Disc., 476–482, Nov., 1923.)—The author assumes that Bohr's theory of the atom is true, that the non-polar, as opposed to the polar link, consists in the sharing of two electrons between the two linked atoms, and that the orbit of each shared electron includes both of the attached nuclei. The results obtained by applying this conception to the chemical facts are considered. The theory advocated in various forms by Flürscheim, Lapworth, Robinson, and others is discussed and Lowry's theory of the nature of the double link is adversely criticised. **J. J. Thomson, R. H. Fowler, W. A. Noyes, W. Bragg, V. Henri, C. R. Bury,** and **T. M. Lowry** took part in the discussion. T. H. P.

1019. *Recent Contributions to the Theory of Induced Alternate Polarities in a Chain of Atoms.* **A. Lapworth** and **R. Robinson.** (Faraday Soc., Trans. 19. pp. 503–505, Nov., 1923.)—The authors criticise adversely some recent publications dealing with the principle of induced alternate polarities deduced by Lapworth and by Kermack and Robinson. In particular, objection is taken to Lowry's theory of mixed double bonds, which fails to suggest any explanation of the above principle and is, moreover, inadmissible, since it introduces theoretical limitations where no distinctions are perceivable in practice. The appearance of graded electrovalencies in activated molecules and possibly in normal molecules containing carbonyl and similar unsymmetrical groups, were postulated by the authors prior to the publication of Lowry's work. T. H. P.

1020. *Octet Stability in Relation to Orientation and Reactivity in Carbon Compounds.* **R. Robinson.** (Faraday Soc., Trans. 19. pp. 506–507, Nov., 1923.)—With the object of clearing up misunderstandings concerning the explanation of the alternating polar effect advanced by Kermack and Robinson [Abstract 1794 (1922)], the author discusses further several points of the subject. T. H. P.

1021. *Nuclear Tubes of Force and Bonds of Variable Polarity in an Atom.* **H. Henstock.** (Faraday Soc., Trans. 19. pp. 508–513, Nov., 1923.)—Various suggestions are made in order to remove difficulties encountered in the application of the principle of induced alternate polarities of atoms, advanced by Lapworth and by Kermack and Robinson [Abstracts 1794 (1922) and 1523 (1923)]. T. H. P.

1022. *Chemical Combination and Activation.* **E. K. Rideal.** (Faraday Soc., Trans. 19. pp. 514–517, Nov., 1923.)—The part played by activation in determining chemical reactions of various types is discussed. T. H. P.

1023. *The Electronic Theory of Valency.* (Faraday Soc., Trans. 19. pp. 518–537, Nov., 1923.)—The papers by A. Lapworth, R. G. W. Norrish, E. E. Walker, W. A. Noyes, J. Kenner, J. F. Thorpe, I. M. Heilbron, G. N. Burkhardt, R. Robinson, G. N. Lewis, T. M. Lowry, C. R. Bury, B. Flürscheim, and W. E. Garner, referred to in preceding abstracts are discussed. T. H. P.

1024. *Mechanism of Metallic Corrosion.* **G. D. Bengough** and **J. M. Stuart.** (World Power, 1. pp. 25–34, Jan., 1924.)—Metallic corrosion is the oxidation of the metallic substance, the term oxidation being used in its widest sense; and is not restricted merely to addition of oxygen to the metal. The oxidation may take place (1) by the direct union of the metal and oxygen, (2) by replacement of hydrogen; hydrogen may or may not appear as a gas. Considerable discrepancies are found between the rate of corrosion and differences of strain, composition conductivity of electrolyte, solubility of oxygen in the electrolytes, and the position of the metal in the electrode potential series. The reason for the discrepancies is ascribed to the formation of scales.

The scales may be crystalline, vitreous, and gelatinous. The nature of the scale is of fundamental importance in the study of corrosion. The corrosion of aluminium and copper was studied, as types of industrial metals. The behaviour of each metal was tested in common types of water, under three sets of conditions, namely, completely immersed in stagnant water, when subjected to a jet of water with and without entangled air, and when alternately wetted and dried. The corrosion is rapid if the scale is soluble in the electrolyte; it is slow if the scale is not mechanically or chemically affected by the electrolyte. The production of pores or cracks in the scale by chemical or physical means results in pitting of the metal. F. J. B.

1025. *Corrosion of Iron in Water and in Neutral Salt Solutions.* **J. A. N. Friend.** (Chem. Soc., J. 123. pp. 2996–2999, Nov., 1923.)—Adeney and his co-workers [Abstract 2464 (1922)] find that dry gases are absorbed at room temperature about twice as rapidly as the gases saturated with moisture. The reason for this appears to be that evaporation of water into the dry gas cools the saturated surface layers, which continuously sink or "stream" into the bulk of the liquid, thereby inducing circulation and more rapid aeration. In agreement with these results, experiments now described by the author show that water exposed to dry air is approximately twice as corrosive towards immersed iron as is water exposed to air saturated with water-vapour. It appears, therefore, probable that satisfactory "repeat" results might be obtainable in corrosion experiments if the humidity of the air, in addition to the other factors, could be controlled.

Adeney found also that the rate of dissolution of nitrogen in dilute solutions of sodium chloride at first increases to a maximum, and afterwards diminishes as the concentration of the salt increases. On the assumption that oxygen behaves similarly in this respect to nitrogen, it becomes possible to explain the relative rate of corrosion of iron immersed in salt solutions. The rate C is determined by four main factors: the chemical action of the dissolved salts, χ; the solubility of oxygen, β; the rate of dissolution of oxygen, R, and the rate of precipitation of the corrosion catalyst, namely, colloidal iron hydroxide, by the negative ions ϕ. On the assumption that C is proportional to χ and to $1/\phi$, it follows that $C \propto \chi\beta R/\phi$. Of the various factors, χ and ϕ are less easily determined than β and R, but for dilute solutions of sodium chloride, χ and ϕ are small and approximately constant, so that for any concentration m of the salt, $C_m = \beta_m R_m$, where β and R are expressed as percentages of the values for distilled water under otherwise identical conditions. Experimental results obtained are in satisfactory agreement with this equation. T. H. P.

1026. *The De-Zincification of Brass.* **R. B. Abrams.** (Am. Electrochem. Soc., Trans. 42. pp. 39–50; Disc., 51–54, 1922.)—Experiments are recorded, the results of which indicate that the mechanism of de-zincification is as follows: The first step is the dissolving of the brass as a whole. The copper in solution then redeposits, replacing brass as a unit. This redeposition will not take place unless there is some means of holding the dissolved copper in contact with the brass. This can be accomplished in two ways, one by the presence of a membrane, the other by having a large excess of dissolved copper present. Obviously this latter possibility is a remote one, especially so far as natural conditions are concerned. The membrane may be anything whatsoever, so long as it performs the function of keeping the dissolved copper in contact with the brass. Whether or not de-zincification shall take place can be controlled by merely supplying or taking away the membrane. AUTHOR.

1027. *The Preparation and the Mechanical Properties of Vacuum-Fused Alloys of Electrolytic Iron with Carbon and Manganese.* **R. P.**

Neville and **J. R. Cain.** (Am. Electrochem. Soc., Trans. 42. pp. 21–36; Disc., 36–37, 1922.)—This paper describes the preparation and mechanical properties of an extensive series of very pure alloys of electrolytic iron, carbon, and manganese, whose compositions were so chosen as to bring out the specific effects on pure iron of additions of manganese, additions of carbon, and additions of carbon and manganese together in varying relative proportions. The maximum content, each of carbon and manganese in each series, is about 1·6 per cent.; the minimum, 0 per cent., or pure iron. Three-pound ingots of the alloys were made by melting electrolytic iron under vacuum in an electric furnace in a crucible of pure magnesia, to which the carbon and manganese were added after fusion of the iron. From these ingots tensile specimens were made and tested in the annealed state. The data were tabulated in the order of increasing carbon for comparison and interpretation of results, and are shown as graphs. [See also Abstract 1253 (1923).] AUTHORS.

1028. *Some Electrical Properties of Alloys at High Temperatures.* **M. A. Hunter** and **A. Jones.** (Am. Electrochem. Soc., Trans. 42. pp. 159–178; Disc., 178–180, 1922.)—The materials used in the heating elements of commercial units may be divided into two classes. The first class comprises those which require materials with high specific resistance at the operating temperature. The second class includes those materials which in addition to having a high specific resistance must also withstand oxidation. The first class of materials can be operated successfully at temperatures not exceeding 500° C. The second class may be used with more or less satisfaction up to 1100° C. From the data contained in this paper the specific resistance of any material in either class at any operating temperature may be calculated. In the first class the various grades of nickel have been investigated, together with two alloys of copper and nickel—"Monel" and "Advance"—and two alloys of iron and nickel. In the second class the various grades of nichrome have been considered. Some information on the relation between the resistances of bright and oxidised wire is also given. AUTHORS.

1029. *Effect of Heat Treatment on the Hardness and Microstructure of Electrolytically Deposited Iron.* **N. B. Pilling.** (Am. Electrochem. Soc., Trans. 42. pp. 9–17; Disc., 17–20, 1922.)—Some physical changes accompanying the heating of pure electrolytically deposited (kathode) iron have been studied. The initial effect of annealing is a very marked hardening, reaching a maximum at an annealing temperature of 300–400° C. The corresponding scleroscope hardness number is 45. At the same time the initial brittleness is removed. Heating at higher temperatures results in progressive softening, consummated above the A_3 temperature (900° C.). Microstructural changes and the rate of decomposition of the unstable iron-hydrogen compound are discussed in relation to the hardness changes. AUTHOR.

1030. *Tempering Soft Steels at very High Temperatures.* **Sauvageot** and **H. Delmas.** (Rev. de Mét. 20. pp. 777–795, Dec., 1923.)—This paper contains an account of certain researches on soft steels (containing less than 0·2 per cent. of carbon) tempered at high temperatures. A description is given of the methods employed, and the results are expressed in tabular and graphical form. A number of photomicrographs are also included. Typical chemical analyses, mechanical test results, and heat treatment data are given. A. W. J.

1031. *X-Ray Analysis of Solid Solutions.* **E. A. Owen** and **G. D. Preston.** (Phys. Soc., Proc. 36. pp. 14–30; Disc., 30, Dec., 1923.)—Examination by means of the X-ray spectrometer of the atomic structures of solid solutions of copper-aluminium, aluminium-magnesium, and copper-nickel shows that, in each case, the solute atom replaces an atom in the lattice of the solvent, this substitution being accompanied by distortion of the lattice. Examination of a saturated solution of aluminium in copper shows that the aluminium expands the copper lattice from 3·60 to 3·65 Å. The effect of adding nickel to copper is to produce a contraction of the lattice, the contraction being approximately a linear function of the atomic percentage of either constituent. Addition of 8 per cent. of magnesium to aluminium increases the average parameter from 4·05 to 4·10 Å., whilst addition of 8 per cent. of aluminium to magnesium diminishes the average parameter of the hexagonal lattice of magnesium from 3·17 to 3·15 Å., and increases its axial ratio from 1·63 to 1·66.

Examination of the eutectic alloy of aluminium and copper showed that this alloy consists of a mixture of two distinct substances with different space lattices; the one is $CuAl_2$ and the other a substance with a space lattice indistinguishable from that of pure aluminium. The compound $CuAl_2$ possesses a simple tetragonal lattice of side 4·28 Å. and axial ratio 0·562, the copper atoms being at the corners and the aluminium atoms at the centres of the four small faces. The atomic structure of the compound CuAl resembles that of a solid solution of aluminium in copper, but the distortion is considerably greater; the material has a face-centred trigonal lattice of side 3·89 Å. and an angle between the axes of 94·6°, the 111 planes being composed alternately of aluminium and copper atoms. T. H. P.

1032. *X-Ray Analysis of Zinc-Copper Alloys.* **E. A. Owen** and **G. D. Preston.** (Phys. Soc., Proc. 36. pp. 49–65; Disc., 65–66, Dec., 1923.)—Alloys containing up to 38 per cent. of zinc, constituting the α-brasses, are found to possess a face-centred cubic lattice, the parameter increasing from 3·608 Å. for pure copper to 3·696 Å. for the 38 per cent. of zinc alloy. Solution takes place by the substitution of zinc atoms for copper atoms. X-ray analysis of a brass with 48·5 per cent. of zinc shows that the β-brasses possess a centred cubic structure, the side of the unit cube being 2·946 Å. Specimens quenched from 550° and annealed below 470° give identical spectra and show no sign of the presence of the α-phase. The evolution of heat observed at 470° is not accompanied by a change of crystal structure and is similar to the α-β-transformation of iron; it is not associated with resolution of the β constituent into a mixture of the α and γ components. Of specimens containing 43·7 per cent. of zinc, that annealed at 750° and quenched showed the reflections due to β-brass alone, whilst that annealed at 500° and quenched, and that annealed at 400° consist of mixtures of the α- and β- phases; the results of X-ray analysis agree with the constitutional diagram given by Shepherd. The γ-phase crystallises on a rhombohedral hexagonal structure of side 4·136 Å. and axial ratio 0·6495, and the ε-phase gives a spectrum characteristic of a close-packed hexagonal lattice of side 2·718 Å. and axial ratio 1·585.

The system zinc-copper crystallises on a rhombohedral hexagonal lattice from copper to γ-brass and on a close-packed hexagonal system from ε- (or possibly δ)-brass to zinc. The observed parameter of the lattice of ε-brass suggests that the copper atom causes the zinc atom to rotate about an axis perpendicular to a $11\bar{2}0$ plane until the zinc atoms in successive 0001 planes are separated by a distance equal to the side of the lattice of pure zinc; fusion would then occur at about the same temperature in both cases. For the alloy containing 10 per cent. of copper the density is found to be 7·35 and not 6·8 grms. per c.c., as stated by Bamford; all the observed densities are in good agreement with the values computed from X-ray data.

The hardness of the brasses attains a maximum in the region of γ-brass, where the atomic volume curve shows the greatest departure from the straight line joining the atomic volumes of copper and zinc. The hardness of the α-phase is ascribed to local distortion and that of the β-phase to the difference in type of lattice. The relatively very great hardness of γ-brass is due to low atomic volume and loss of symmetry. The fact that the atomic volume curve consists of two straight lines suggests the existence of an allotrope of zinc with atomic volume 13·92 Å. and consideration of the value of the parameter of the lattice of the β-phase suggests that this phase is due to an allotropic modification of copper with the atomic volume 12·79 Å. T. H. P.

1033. *Some Refinements of the Theory of Dissociation Equilibria.* **C. G. Darwin** and **R. H. Fowler.** (Cambridge Phil. Soc., Proc. 21. pp. 730–745, Nov., 1923.)—The authors have lately published a series of papers [see Abstracts 713 and 714 (1923)] giving simpler methods for the proof of theorems of statistical mechanics. The starting-point of the mathematical calculus given is the identity between expressions naturally occurring and the coefficients of a multinomial expansion. For more complicated problems, such as gas reactions, the multinomial theorem is not applicable, and use was made of older methods, in which Stirling's theorem was used in part of the problem. It is now shown that by a slight modification the same methods may be used for the general problem as for the simpler ones. The expressions required are still coefficients in certain expansions in multiple power series, but to sum them use is made of the exponential instead of the multinomial theorem. The required coefficients are then picked out by a multiple instead of a simple complex integral. The single "selector variable" used in the authors' earlier method has a physical counterpart in the temperature. In the new theory the extra selector variables are shown to correspond to the partial potentials of thermodynamical theory. The paper contains little or no discussion of physical questions, but is concerned mainly with the new mathematical technique. T. B.

1034. *Influence of Polarisation upon Photo-Voltaic Effects.* **R. Audubert.** (Comptes Rendus, 177. pp. 1110–1112, Nov. 26, 1923.)—An arrangement is described whereby the two plates of the cell are kept at the same potential but differing from that of the electrolyte. It was found that for platinum, copper, and mercury a positive polarisation of the illuminated electrode diminishes the photo-voltaic effect, whilst a negative polarisation augments it. The converse effects were found for gold and silver. In each case there is some critical polarisation which just balances the effect produced by illumination. A mechanism of the phenomenon is advanced in terms of the photoelectric effect. [See also Abstract 690 (1924).] A. A. D.

1035. *Significance of Electrode-Potential.* **J. A. V. Butler.** (Roy. Soc., Proc. 104. pp. 667–670, Dec., 1923.)—Heyrovsky's cycle [Abstract 1268 (1923)] is not reversible, and his conclusions are therefore not valid. A reversible cycle has been devised; but, since the sum of the differences of potential round the cycle is zero, it gives no information as to relations between electrode-potentials and chemical equilibrium constants. T. M. L.

1036. *Use of the Quinhydrone Electrode for the Estimation of Amino-Acids, and of Acids and Bases.* **L. J. Harris.** (Chem. Soc., J. 123. pp. 3294–3303, Dec., 1923.)—In pigmented solutions where indicators cannot be employed, the quinhydrone electrode furnishes a convenient method for estimating basic and acidic functions. Titration curves are obtained with much greater ease than with the hydrogen electrode. The experimental figures must be corrected to allow for the volume of titrant required to bring the pure solvent to the same volume and P_H value. From the curve the hydrogen-ion concentration is deduced. The end point may also be obtained by setting the potentiometer to a standard reading and titrating to zero deflection, the corrected volume of titrant being proportional to the original concentration of material to be titrated.

The method is employed for the estimation of amino-acids or amino-groups in a mixture, by the application of the law of mass action and the theory of titration. Its use for the estimation of lysine, arginine, and histidine, glutamic and aspartic acids, either alone or in mixtures, is described. The electrode may be used for the estimation of all but the weakest acids, and for bases of any strength, provided no reaction takes place with the quinhydrone. B. W. C.

1037. *Velocity of Hydrogen Ions in Gels.* **N. Isgarischew** and **A. Pomeranzewa.** (Zeits. Electrochem. 29. pp. 581–586, Dec., 1923.)—A modification of Lodge's method was used to determine the velocity of hydrogen ions in gelatine. Gelatine was dissolved in water at 37° C., and sufficient of each salt added so that the resulting solution was exactly normal in respect to that salt. Methyl orange was added to the solution, which was poured into a graduated tube and allowed to set. The movement of the coloured boundary under constant voltage was observed at 17°–18° C. The velocity of $H^\cdot$ diminished with increase of gelatine concentration, and increased proportionally with increase of voltage. The effect of different kations in the gelatine upon the velocity of the $H^\cdot$, is directly related to the atomic volumes of the kations. The kations investigated were: NH_4, Rb, K, Na, Li, Mg, Zn, Cd, Mn. An attempt is made to explain the mechanism and cause of the relationship between velocity of hydrogen ions and atomic volumes of the kations. F. J. B.

1038. *Electro-Analytical Estimation of Thallium by Anodic Deposition of Thallic Oxide.* **W. Dieterle.** (Zeits. Elektrochem. 29. pp. 493–495, Oct., 1923.)—Conditions have been determined for the estimation of thallium by electrolysis of an aqueous solution of thallous nitrate containing nitric acid and either alcohol or acetone. The containing platinum dish, which is roughened, is made the anode, and the kathode consists of iridium-containing platinum and makes 300 rotations per minute. The temperature is maintained at 60–63°. The method yields satisfactory results. T. H. P.

1039. *New Method of Titrating Silver and Halogen Ions with Organic Dye Indicators.* **K. Fajans** and **O. Hassel.** (Zeits. Elektrochem. 29. pp. 495–500, Oct., 1923.)—Very dilute solutions of the alkali salts of fluorescein and its halogen substitution products show characteristic colour changes in presence of silver halide sols if the solutions contain excess of silver ions. These colour changes are attributed to the association of the dye anions with the excess of silver ions absorbed by the silver halide. By this association the electronic envelopes of the dye anions undergo change similar to that occurring in the formation of pure silver and other salts in the solid state. In some cases the colour changes produced by excess of halogen ions may be reversed by excess of halogen ions, the latter displacing the dye anions from the surface of the silver halide; the readiness with which this proceeds depends on the adsorbabilities of the halogen and dye ions, the absorbability increasing in the series: Cl, Br, I, and in the series: fluorescein, dibromo, tetrabromo-, di-iodo-, and tetra-iodo-fluorescein.

Owing to this behaviour, fluorescein may be used as indicator in titrating chlorine ions with silver ions, and fluorescein or its dibromo- or tetrabromo-derivative in titrating bromine or iodine ions. With a mixture of chlorine and iodine ions the latter alone may be estimated if eosin (tetrabromofluorescein) is used as indicator, and chlorine and iodine ions together if fluorescein is used. T. H. P.

1040. *Electrometric Estimation of Vanadium and Uranium Separately, Together, and when Mixed with Iron.* **E. Müller** and **A. Flath.** (Zeits. Elektrochem. 29. pp. 500–508, Oct., 1923.)—From a repetition of the work of Gustavson and Knudsen [Abstract 594 (1923)], various modifications are suggested in the conditions to be observed in the electrometric estimation of vanadium, uranium, and iron. T. H. P.

1041. *Electrosmosis and Electrophoresis.* **O. C. Ralston.** (Am. Electrochem. Soc., Trans. 42. pp. 269–272, 1922.)—The terms "electrosmosis," "electrophoresis," "kathodophoresis" and "anodophoresis" are proposed (1) to replace a large number of other words, some of which are incorrectly used and all of which are awkward; (2) to gain uniformity of nomenclature in conformity with the two words "electrolysis" and "electrostenolysis"; and (3) to provide single descriptive nouns, which when properly modified can be used as verbs, adjectives, or participles that easily displace present clumsy phrases. AUTHOR.

1042. *Electrolytic Generator for Pure Hydrogen.* **Elveden** and **E. Sinkinson.** (Chem. Soc., J. 123. pp. 2715–2716, Oct., 1923.)—For supplying pure hydrogen in connection with the measurement of hydrogen-ion concentration use may be made of ten electrolytic cells, connected in series and each composed of an outer boiling-tube 12 inches long and 1¾ inches wide and of an inner tube 12 inches by ¾ inch, this being open

below and fitted axially into the outer tube by means of a waxed cork, carrying also the anode and the oxygen escape tube. Through a stopper at the top of the inner tube pass the kathode and a tube 2 inches long for the delivery of the hydrogen. The electrodes are of pure nickel wire of No. 10 gauge, and are bent so that one wire forms the kathode of one cell and the anode of its neighbour, and the electrolyte consists of saturated barium hydroxide solution. The cells deliver hydrogen to a common main and are preferably mounted in two banks, each of five. The pressure of hydrogen in each cell should be no greater than is necessary to allow of half an inch of electrode being covered by the baryta in the inner tube, this being regulated by connecting the common main with a wash-bottle fitted with an adjustable inlet tube; if the pressure is too great, the electrolyte will be forced below the end of the electrode and arcing will result. Any traces of methane that might be formed may be destroyed by passing the gas through a tungsten filament lamp heated by a current which causes it to glow without melting the filament when the lamp has been completely filled with hydrogen. The generator is connected in series with a resistance of 70 ohms to the mains at 220 volts; it then consumes 1·5 amperes and delivers 6 litres of hydrogen per hour.
T. H. P.

1043. *The Addition of Colloids during Electrolysis, and Over-Voltage Phenomena.* **C. Marie** and **R. Audubert.** (Soc. Franç. Élect., Bull. 3. pp. 508–533, Aug.–Sept.–Oct., 1923.)—The authors give a brief survey of over-voltage effects with hydrogen and oxygen, and show that owing to the number of factors, such as temperature, current-density, and nature of the surface, which must be considered, no completely satisfactory explanation has so far been advanced. It is known that the addition of colloids to an electrolytic bath produces a coherent deposit of metal. Experiments with acid baths show that this addition results in an increased decomposition potential in the case of electrodes, such as lead, zinc, and copper, which exhibit overvoltage phenomena. Similar effects are observed in the decomposition of metals. The action of colloids is therefore to increase the potential difference at the electrode, thereby increasing the rate of development of crystal nuclei compared with crystal faces, producing small crystals and a coherent deposit. Experiments on the absorption of ions by gum mastic and the influence of gelatin on concentration cells of silver salts indicate that the colloids adsorb the ions of electrolyte according to the relation $U = AC^p$. It is probably the electrostatic effect of these adsorption complexes which accounts for the increased potential difference caused by the addition of colloids, but owing to the complexity of the problem this cannot be accepted as definite without further systematic research.
B. W. C.

1044. *Electrolytic Deposition of Alloys Sb-Cu and Sb-Bi.* **A. Mazzucchelli** and **Lucia Tonini.** (Accad. Lincei, Atti, 32. ii. pp. 290–292, Nov. 10, 1923.)—Under different conditions, alloys Cu_2Sb and Cu_3Sb are deposited, with small percentages of $SbCl_3$. With bismuth, the results are not as clear, but alloys are deposited.
A. D.

1045. *Some Properties of Electrolytic Manganese.* **A. N. Campbell.** (Chem. Soc., J. 123. pp. 2323–2327, Sept., 1923.)—The density of electrolytic manganese is found to be 7·034–7·080, the possible presence of interstices, either vacuous or filled with hydrogen, rendering these values minimum ones. The powdered metal is not attacked by cold water, and the action of boiling water or steam is very slow. Manganese dissolves readily in dilute hydrochloric, sulphuric or acetic acid, and the amount of sulphur dioxide evolved when it is boiled with concentrated sulphuric acid corresponds with the equation:

$$Mn + H_2SO_4 = MnSO_4 + 2H_2O + SO_2.$$

With nitric acid the metal gives a mixture of nitrogen peroxide, nitric and nitrous oxides, and hydrogen, varying in composition with the concentration of the acid. Other chemical properties are described. Manganese readily displaces arsenic, antimony, bismuth, tin, lead, copper, iron, nickel, cobalt, cadmium, and zinc from solutions of their salts; chromium salts were not tried. At 12° the single electrode potential is − 0·797 volt (absolute scale), this value becoming more highly negative with dilution of its salt solution. At 16° the hydrogen overvoltage at a manganese surface varies from 0·615 volt at 0·47 to 1·044 volt at 10 amperes per sq. dm.; with the constant current-density 3·33, it varies from 0·801 volt at 15·5° to 0·393 volt at 84°. At 13° the potential was found to be − 0·795 volt with no current flowing, and to remain constant at − 0·725 volt with a current-density varying from 0·7 to 7 amperes per sq. dm.; 0·070 volt being thus the measure of the passivity.

T. H. P.

1046. *Electroplated Zinc and the Diffusion of Electro-Deposits into Zinc.* **W. G. Traub.** (Am. Electrochem. Soc., Trans. 42. pp. 55–59; Disc., 59–62, 1922.)—Experiments were made to determine the cause of the disappearance of certain metals that had been deposited on zinc. The results indicate that copper, brass, gold, and silver are diffused into zinc; whereas nickel, which does not diffuse into zinc, can be used as a preventive against diffusion of other metals deposited over it. Author.

1047. *Apparatus for Electrolytic Separation of Metals.* **A. Lassieur.** (Comptes Rendus, 177. pp. 1114–1116, Nov. 26, 1923.)—The electrolytic separation of several metals present together in a solution requires an auxiliary electrode to control the potential difference between the kathode and electrolyte. The author has devised a simplified form of apparatus for this purpose, the potential being read directly on a voltmeter instead of using a potentiometer; a resistance of 25,000 ohms in series allows various galvanometers to be employed without materially affecting the circuit resistance. A mercury electrode is used for the auxiliary cell, while the electrolyte is contained in a specially devised cell which permits agitation of the liquid. The procedure necessary to obtain effective separation is described; bismuth and copper may be separated by this method, which the author claims has never before been accomplished by purely electrolytic means.

B. W. C.